Product Engineering

A McGRAW-HILL PUBLICATION

Five Dollars a Year

DECEMBER 1952

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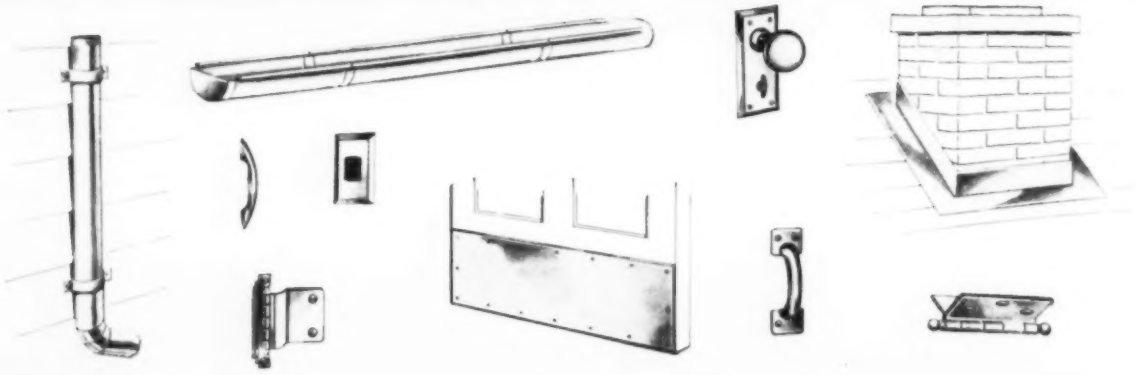
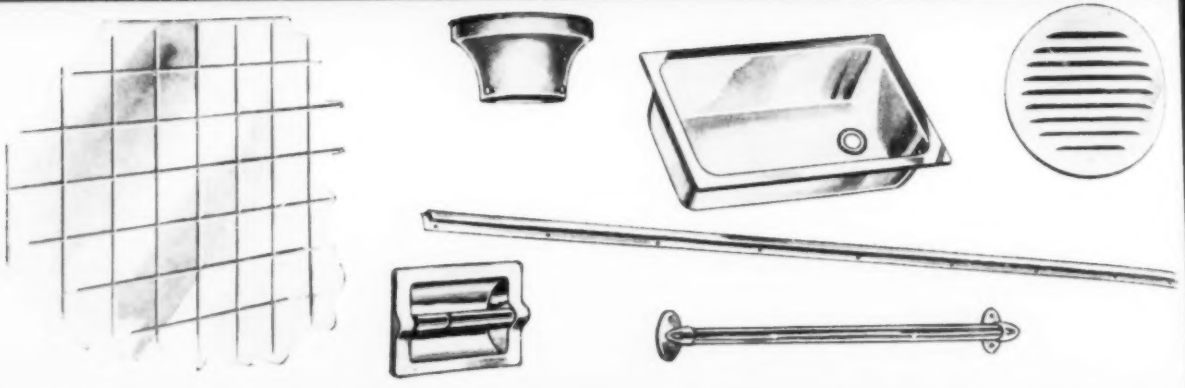
If you are a manufacturer of building products



and are caught in the critical material squeeze



and are looking for a way out . . .

Many manufacturers of building materials find their production seriously threatened by NPA directives limiting or prohibiting production of their products from critical materials. Especially hard hit are manufacturers of building materials normally made of 18-8 stainless, brass, copper, aluminum, or chrome plated.

If your operations fall in any of these categories, then you will want to know more about Sharon '430' Stainless Steel. It is the best available material today for many such applications. Sharon '430' is a straight chromium grade of stainless with a record of successful application. It is readily available with few restrictions as to end use. It may fit your production setup perfectly. If so, your critical material worries are ended.

Get the facts on this popular stainless today. Contact your nearest Sharon representative or write direct. Engineering data and technical assistance are available without obligation. A new booklet describing how to use Sharon '430' Stainless may be obtained by writing direct to ***Sharon Steel Corporation, Department 71252, Sharon, Pa.***

Those manufacturing gutters, downspouts, flashing, etc., will want a copy of the new information-packed booklet *Sharon '430' for Better Roof Drainage Systems*. Available from district sales offices or by writing direct.

your answer is *Sharon* 430 *stainless steel*

SHARONSTEEL

VOLUME 23 **Product Engineering** NUMBER 12

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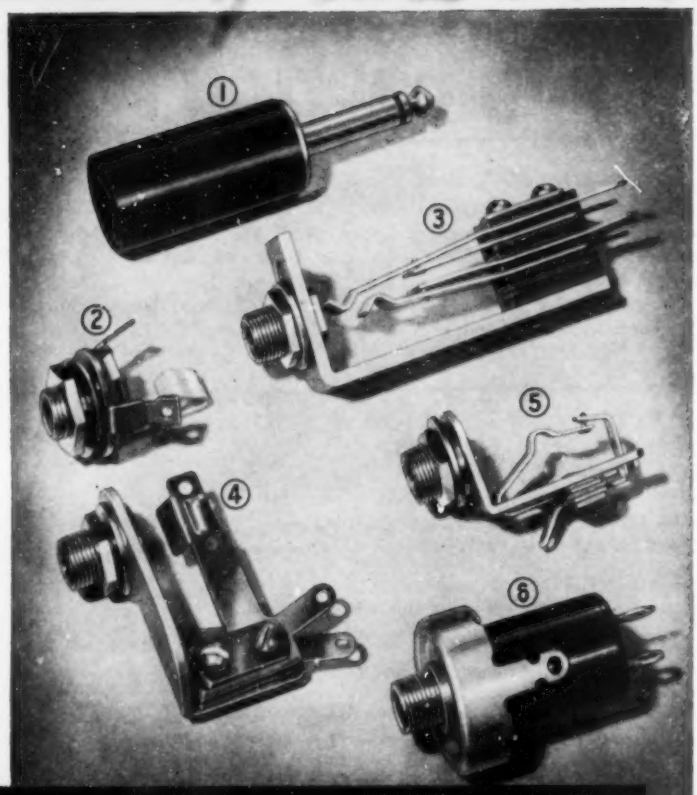

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The complete line of Mallory jacks, jack switches and plugs is designed to fit an infinite range of circuit possibilities. They are sturdily built and will meet exacting specifications of performance and dependability for manufacturers of communications, testing and low-power industrial equipment as well as many highly specialized electric and electronic devices.

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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio.

Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear

NONMETALLIC MATERIALS

SPECIAL FORM of natural rubber which is claimed to be completely resistant to moisture has been announced by the Linatex Corp of America, Rockville, Conn. Material is said to be three to four times more resilient than other rubbers, light in weight, and have exellent low temperature characteristics. Permanent adhesion can be obtained on most surfaces including metal, wood, concrete, Fiberglas, and rubber.

SQUARE OR RECTANGULAR shaped paper tubes with rounded corners are available from Precision Paper Tube Co., Chicago, Ill. Tubes up to 9 in. sq. are spirally-wound of dielectric kraft, fish paper, cellulose acetate or combinations to lengths as specified. Where increased dielectric properties or high resistance to moisture are essential, special wrappings are available.

HEAT-RESISTANT PAINT made of copper flakes in a silicone base has been announced by Speco Inc. Cleveland Ohio. Claimed to withstand temperatures up to 1,700 F, paint fuses to metal surfaces forming a solid copper coating which contracts and expands with temperature. High copper contents prevent rust, and provides resistance to corrosion from mild acids.

RUBBER-MOUNTED COMPONENTS can be securely held with a new silicone resin, designated SR-98, by GE's Chemical Div. at Pittsfield Mass. Said to have excellent bonding strength and lack of flow at elevated temperatures, compound forms a hard, tough insulating film.

ACID RESISTANCE and ability to withstand thermal shock describes CRC-14, a porcelain enamel coating for steel, developed by the Seaporcel Metals Inc, Long Island City, N. Y. Characteristics of the new finish when applied to low-carbon steel are reported to compare favorably with those of stainless steel.

A MODIFIED PHENOLIC RESIN known as Phenoline 300, has been developed as a corrosion resistant coating. Carboline Co, St. Louis, Mo. claims it will bond to nearly any surface and has a temperature range of -70 to 400 F. Can be used as a lining, paint or seal for porous castings and for repairing leaks in welded and riveted tanks.

HIGH TEMPERATURE thermosetting plastic for electrical components has been developed by Melkor Research Laboratories Inc., Cleveland, Ohio. Called Melkorite, it is claimed to withstand continuous operating temperatures of 392 F and to have high dielectric strength. It is applicable to terminals and eyelets and is advantageous for use where hermetic sealing and gas sealing under pressure is needed for perfect operation.

METALLIC MATERIALS

FIVE ALLOYS of aluminum have proven satisfactory for enameling purposes. Dupont states that 2S, 3S, 53S and 61S in the wrought alloys and casting alloy No. 43 have been used. The latter three require an alkaline chromate bath after cleaning before processing. Enameled aluminum can be cut, and sheared.

RESEARCHERS are studying the possibilities of getting titanium from ilmenite instead of rutile and magnesium, as is now the case. If the studies prove succesful, DPA predicts a substantial increase in titanium production as ilmenite is available in this country. Half of the rutile now used is imported from Australia.

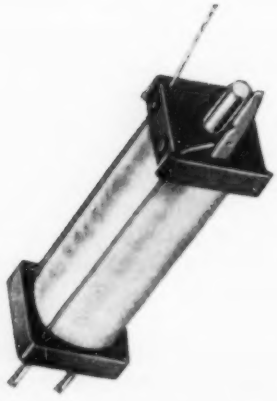
COLD-ROLLING of cartridge brass to effect recrystallization has indicated that the annealing time for complete recrystallization is shorter when the condition of high deformation, high annealing temperature, and small initial grain size exist. Kaiser Aluminum and Metals Corp. also states that the recrystallized grain size is independent of the annealing temperature and the rate of growth decreases at 600 centigrade.

(continued on page 7)

ASK FEDERAL TELEPHONE AND RADIO ABOUT KURZ-KASCH MOULDED PLASTICS!

ASK ABOUT THE PROBLEM! This moulded plastic spool assembly consists of two parts—both intricate and delicate challenges to the moulder. The front part is moulded with a threaded brass insert, an iron core, an extended contact point plus four moulded .093" dia. bosses. Rear assembly has as integral parts a threaded brass insert, three minute pin type terminals, plus four .046" dia. through cored holes and one cored hole for mounting. They're shown here actual size.

ASK ABOUT K-K MOULD-MAKING SERVICE! These parts were needed fast. The numerous inserts moulded in at all angles necessitated complete cavities disassembled on the bench for ejection. Yet our first 4-cavity transfer mould with 2 sets of impressions was ready for production *ahead* of a very tight schedule.



ASK ABOUT K-K MOULDING PRODUCTION! Shipments are required in quantity—and on specified schedules, of course. And that's just the type of service that we specialize in delivering!

THEN ASK YOURSELF . . . *"If Kurz-Kasch can keep on satisfying leading manufacturers like Federal Telephone and Radio Corporation—and as long as it has had a record like that for over 36 years—why don't we try Kurz-Kasch ourselves?"* WHY NOT? We solicit your inquiry.

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EXPORT OFFICE: 89 Broad Street, New York City, *Bowling Green 9-7751.*

Kurz-Kasch
FOR OVER 36 YEARS PLANNERS AND MOULDERS IN PLASTICS

530 POUNDS of titanium sheet has replaced steel on a gage-for-gage basis in B-36 aircraft. U.S. Army Air Force announced that the commercially pure sheet is used for non-structural applications and results in a 40 percent weight savings. Electronic equipment is to be added.

HIGH-SPEED STEELS with carbon content of 0.50 percent are excellent for hot working dies, 0.55 to 0.70 percent carbon should be used for cutting tools requiring high resistance to breakage. Vanadium-Alloy Steel Co. also reports that the lowering of carbon content is most effective in obtaining high impact strength.

COMPONENTS

SHOCK RESISTANT, HERMETICALLY SEALED, d-c relay capable of 100 cps operation has been announced by Magnex Corp, Jamaica N.Y. Magnetic balls provide the contacting surfaces for operation. Non-magnetic plating on balls and pole pieces provides long-life contact, avoids sticking by current interruption, and prevents contact holding by residual magnetism. Balls permit even wear of contact surface.

ENCLOSED, non-ventilated dry-type distribution transformer for service on secondary circuits rated 600 v or less has been developed by the Westinghouse Electric Corp. Transformer utilizes Hipersil cores and class H silicone insulation. Smallest unit has a 3 kva rating.

SOLENOID VALVES with adjustable timing on the closing stroke are available for pressure up to 3,000 psi from Atkomatic Valve Co. Indianapolis, Ind. Timing feature is claimed to eliminate shock on supply line, particularly on hydraulic operation. Lightweight valves, are packless, easily maintained, and designed to handle any media not harmful to bronze.

BRANCH CIRCUIT BREAKER that can be installed like a fuse in any standard-base fuseholder has been announced by Mechanical Products, Inc., Jackson, Mich. Available in 15, 20 and 30-amp. ratings unit is a direct replacement for equally rated fuses. Breaker trips instantly on "shorts", but has a built-in time lag to handle temporary starting loads and line surges. Resetting is done by pressing and releasing a reset button. The breaker carries U. L. approval.

PNEUMATIC IN ACTION and containing no rotating or reciprocating parts, air-operated displacement pump is being distributed by Ferro Corp, Cleveland, Ohio. A British development, the pump operates automatically when connected to any compressed air supply line, and pumps liquid in a series of regular suction and discharge strokes. The self-priming pump has no glands, bearings or revolving shafts and can be used for hot, cold and abrasive-in-liquid applications.

BRAKE ACTUATION in 0.005 sec by use of an electronic controller has been announced by the Warner Electric Brake and Clutch Company Belott, Wis. Device can be any distance from the brake and controlled through standard wire connections or by transmitted waves, similiar to radio waves. Also incorporated is a twin stopping circuit that actuates the control in 0.0002 sec in case of a primary failure.

PROCESSES

FRICTION SAWING of metals at saw speeds of 3,000 to 15,000 fpm is announced by the Do All Co., Des Plaines, Ill. Method relies on frictional heat generated between the band teeth and the metal. The heat raises the temperature of the material to about forging temperatures where it is soft and plastic. The teeth bite easily into the softened material, resulting in rapid cutting.

METAL RECOVERY from spent baths, rinse water and electroplating solutions is possible by ion exchange. Being used by the Caterpillar Tractor Co, the process utilizes cation and anion exchangers that give up one ion from their structure for one in the solution being treated. This process continues until ions are exhausted. Cost of recovery is cheaper than dumping.

AVOIDING of stress relieving on welded structures has been accomplished by Lincoln Electric Company. Known as the hidden arc technique, a granular flux is deposited on the joint. This excludes air from the metal while molten, giving a dense ductile, uniform weld. Hidden-arc permits high current density welding.

PROTECTION OF MOLYBDENUM by use of chromium and glass coatings has been investigated by the National Bureau of Standards. Research in-

(continued on page 9)

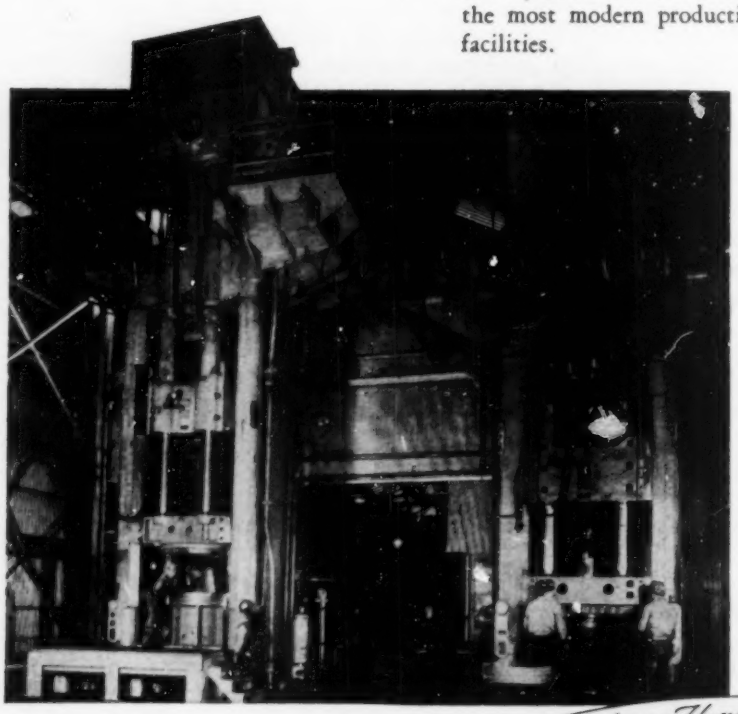
another first!

increases the value of

SCAIFE CONTAINERS

to you

When you specify Scaife Containers as equipment components, you get the benefit of a chain of engineering development that has spanned a century and a half . . . and that is reinforced by the most modern production skills and plant facilities.



Latest example of Scaife pioneering is the perfection of the revolutionary reverse-draw process for producing deep-drawn shapes for pressure vessels and other uses. If you have a container problem where repeat specifications call for strength, lightness, durability, and dependability, this new development may solve your problem. Why not talk it over with us?

One Hundred Fiftieth Anniversary

FOUNDED 1802

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OAKMONT, (Pittsburgh District) PA.

Makers of Pressure Vessels and Drawn Shapes

dicates that the combination of a chromium-base, and a lower-melting-glass coat results in a durable coating that is stable at high temperatures under applied tension. Examination shows that the glass is absorbed into the porous structure of the chromium and reseals the fissures of the coating caused by thermal strain.

REMOVAL of occluded salts after black oxidizing of metals has been developed by the Dulite

Chem. Corp, Middletown, Conn. Known as Dulite "SD", liquid reacts chemically on black oxide salts that remains trapped in rough surfaces of porous, laminated, sintered, or spot-welded parts, thus permitting complete salt removal with a single rinse. Humidity testing indicates no recurrance of occluded salt.

TESTING

INTEGRATED with a test stand for dynamic balancing of rotating parts in the 600 to 40,000 rpm range is a portable dynamic balancer made by International Research and Development Corp, Cleveland, Ohio. The electronic machine has a stroboscopic light that measures without computation the amplitude and frequency of vibration.

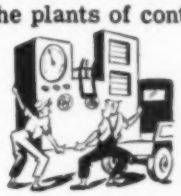
SNAP-AROUND type volt-ammeter which enables instant current measurement has been announced by the Pyramid Instrument Co, Lynbrook, N.Y. A-C instrument has nine scales, six for current and three for voltage, as well as insulated safety plug and jaws. No-rim window floods scale with unobstructed light from the sides. Instrument is pocket-size and belt-mounting.

BEARING for gyroscopic instruments are being checked on a new General Electric Tester, Unit indicates torque variation as a function of angular position during slow rotation in either direction, thereby detecting dirty of defective bearings, prior to installation. Number and magnitude of peaks, average friction and tendency to bind under load are sensed by an elecomagnetic pickup that measures the current drawn by a torque motor in counterbalancing the bearing race torque.

IMPACT TESTS are made on a trapazoidal end-quench bar that has two sides coated with copper to inhibit carburization. General Motors Research Labs indicate that after the other sides have become carburized, tests along the gradient of the carburized area can be conducted without grinding or sawing the bar.

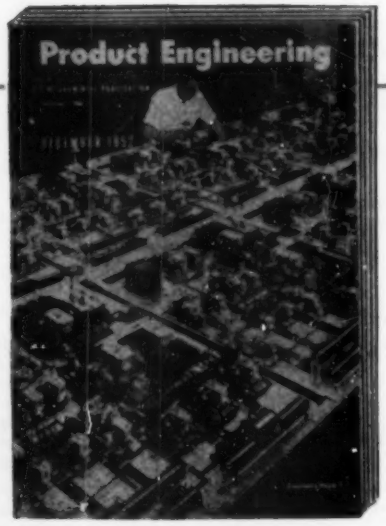
SALT SPRAY TESTER for all ferrous and non-ferrous metals, and organic and inorganic coatings has been announced by Singleton Co, Cleveland Ohio. It is claimed to be inert to all solutions and gases used in the complete range of testing. The units atomizer operates from any plant air system and the heater from a 110-v line.

MOBILE LABORATORY for checking gages in the plants of contractors has been developed by



the Army Ordnance Corp. One to six months out-of-service time saving is expected now that gages do not have to be returned to central laboratories for testing or repairing.

O-RING GROOVES are tested by an indicator gage announced by Reliant Industries, South Gate, Calif. The gage is graduated to 0.0001 in. and a slight rocking motion gives a minimum reading.



THIS MONTH'S COVER

With the strong trend toward automatic machine tool operations, more emphasis is being devoted to the "brain" that controls the machine. The size and complexity that such controls are assuming is evident on this month's cover, which shows the final assembly operations on panels for one type of Blanchard Vertical Spindle Rotary Table Surface Grinder. This grinder, designed for both automatic cycle and manual operation, has the control mounted separately, with push buttons and selector switches at the operator's station.

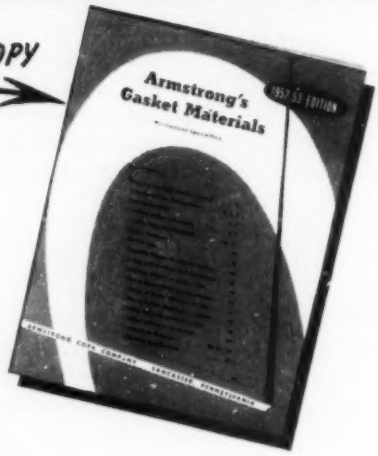
The Square D Company, which produces the control, has created a special job shop operation to cope with problems involved in design and manufacture of automatic controls ranging from those requiring only a few simple components to those employing hundreds of interconnected devices for controlling complex machine tools and processes.

This booklet gives complete information on

CORK-AND-RUBBER GASKET MATERIALS

made to meet government specifications

SEND FOR YOUR FREE COPY



The new edition of "Armstrong's Gasket Materials" has complete, up-to-date information on the Armstrong materials made to meet government specifications. You'll find there's an Armstrong composition for each of the 7 types included in the principal government specifications covering cork-and-rubber gasket materials.

In addition, this 24-page manual is full of helpful ideas on gasket design and use. There are sections on designing gaskets to reduce cost . . . practical tolerances for resilient gaskets . . . how to design flanges for efficient sealing . . . and many other subjects.

You can see "Armstrong's Gasket Materials" in Sweet's file for product designers. If you'd like a personal copy, write Armstrong Cork Company, 7112 Arch Street, Lancaster, Pa.

Here is a list of the Armstrong materials made to meet government specifications on cork-and-rubber gasketing.

Specification	Material	Specification	Material
MIL-G-6183			
Type I Soft	NC-709	Type II Soft	DC-167
Type I Medium	NC-710	Type II Medium	DC-100
Type I Firm	NC-711	Type II Firm	DC-113
MIL-T-6841A	DK-153 or RK-304S	MIL-G-6747	DK-149

For detailed information about these compositions and their application, see Sweet's file for product designers or call your nearest Armstrong office listed below.

New cork-and-rubber compounds. Armstrong's Research Laboratories are ready to develop cork-and-rubber materials to meet new military requirements as they arise. Please discuss your needs with your nearest Armstrong representative . . . or write.

Cork compositions. There is an Armstrong cork composition made to meet each of the classes under Federal Specification HH-C-576, as well as all grades under specification MIL-C-16090.

Synthetic rubber compounds. Armstrong manufactures highly specialized synthetic rubber compounds for certain highly critical applications. If you need an out-of-the-ordinary rubber compound, please discuss your problem with your Armstrong representative.

ARMSTRONG'S GASKET MATERIALS

Your nearest Armstrong Industrial Division office

ALBANY 10, N. Y., 268 Spruce St. at Northern Boulevard, Telephone: 4-0131 • BOSTON 16, MASS., 131 Clarendon Street, Telephone: COpley 7-2490 • CHICAGO 54, ILL., 13-136 The Merchandise Mart, Telephone: DElaware 7-0500 • CINCINNATI 2, OHIO, 301 Temple Bar Building, Telephone: PArkway 3220 • CLEVELAND 15, OHIO, 209 Hanna Bldg. Annex, Prospect Ave. and E. 14th Street, Telephone: MAin 1-7900 • DETROIT 26, MICH., 10th Floor, Free Press Building, 321 Lafayette Avenue, West, Telephone: WOodward 3-5670 • GREENVILLE, S. C., 33 Norwood Place, Telephone: Greenville 3-5302 • LOS ANGELES 15, CALIF., 719 Bendix Building, 1206 Maple Avenue, Telephone: RICHmond 0286 • NEW YORK 16., N. Y., 295 Fifth Avenue, Telephone: MUrray Hill 4-6900 • PHILADELPHIA 2, PA., Robinson Building, Fifteenth and Chestnut Streets, Telephone: LOcust 4-4290 • ST. LOUIS 3, MO., 1205 Olive Street, Telephone: CHestnut 1757 • IN CANADA: Armstrong Cork Canada Limited, 6911 Decarie Boulevard, Montreal, Quebec, Telephone: ATlantic 4733.

DESIGNS QUESTIONS

The designers of these huge machines must bear in mind constantly such questions as:

1. Can the item planned be fabricated?
2. Can it be transported from the source of manufacture to the press site?
3. Can it be maneuvered into position with available equipment?
4. Can the various parts be serviced or replaced easily?

Since the few domestic shops capable of fabricating parts of such magnitude have had a backlog of orders for some time it was necessary for the Loewy Co. to contract with European and Japanese mills to get the needed fabricating capacity.

Another time saving factor in the construction of these presses is the design used for some of the large cylinders required. This design incorporates the multi-layer method whereby concentric layers of high tensile steel 1/4 in. thick are "wrapped" around a cylinder wall 1 in. thick and then welded under tension. This technique results in a saving of 25 percent in time and material. This method is also used in fabricating the accumulator bottles.

ENGINEERING PROBLEMS

The design problems on heavy presses are of a magnitude comparable to the press size. To function effectively and economically these presses are required to have these features: versatility, reliability, high production, accuracy and producibility. They must be able to forge small circular pieces, long spars, thin webs, thin and thick surfaces - all on one press. The press must be rigid enough to take care of off-center loads, or other provisions must be made to compensate for eccentricity. It must operate fast; produce precision forgings; have multiple pressure stages to economize on power consumption; it must produce pancakes and small chunky pieces requiring concentric loads, thin sections requiring the flow of the metal into narrow cavities; it must also take care of spreaded loads. These problems are being thoroughly investigated by all of the press manufacturers involved in this program and are expected to be ironed out as more experience is gained with these presses.

The design and construction of these large presses introduced many associated engineering problems. These include new systems for controlling the presses under varying conditions; new designs for large forging dies; a machine to stretch and detwist the larger extrusions; also new heat treating furnaces and techniques. Personnel problems also were involved. The working conditions of the press operators demanded a solution to the ventilating problem created by smoke due to vaporization of the die lubricants.

PRODUCT DESIGN

From the product design and metallurgical standpoints there will no doubt arise many problems not generally invalued with smaller forgings and extrusions. Included among these will be: stresses set up in cooling; structural soundness in large sectioned parts made from alloys of aluminum, magnesium, nickel, copper and titanium; decarburization and carbon restoration in steel forgings.

It is difficult to evaluate precisely the new aspects of production that will be opened up with the introduction of these mighty tools. While primarily geared to aircraft production there is no doubt that the whole field of metal design and engineering will be greatly influenced. One thing is certain. The nation's design engineers are showing considerable interest in the technical meetings being held on this program and are intently following all the technical developments with an eye toward product improvement.

Speed Nut Savings Stories

YALE & TOWNE LIFT TRUCK "PICKS-UP"

Double Savings Payload

...51% on the Cluster Instrument Panel Installation

...44% on Conduit Installation for the Motor Hoist

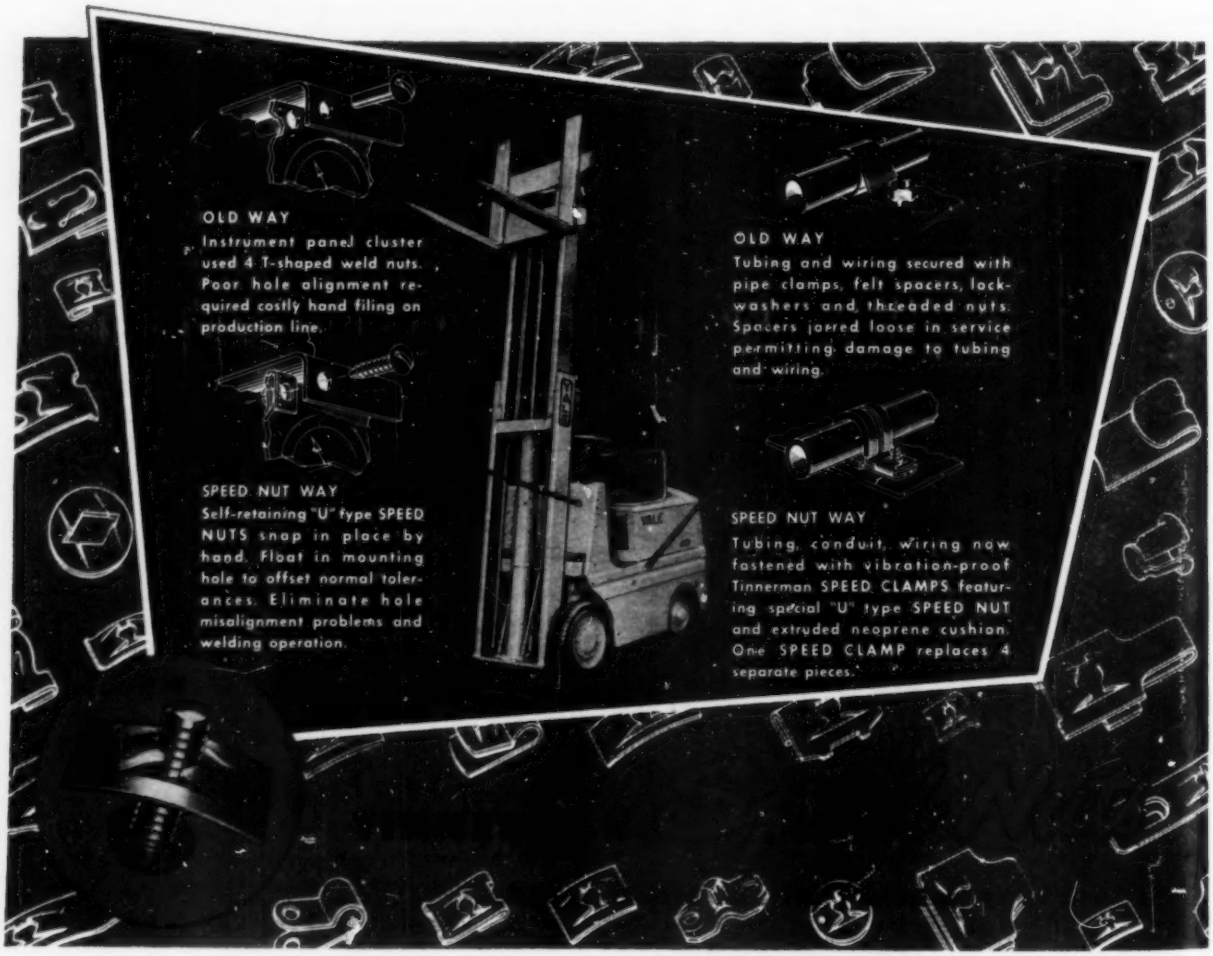
THE heavy-duty lifting and hauling performance expected of these Yale Industrial Lift Trucks means that they must be assembled with fasteners that can take it. That's why engineers at Yale & Towne Manufacturing Company, Philadelphia, Pa. chose SPEED NUTS and SPEED CLAMPS® over all other methods.

They found that Tinnerman self-retaining SPEED NUTS provide rugged, vibration-proof attachments, cut materials handling, and reduce assembly costs! The result in this case was an amazing "double savings payload" of 51%, and 44% in production costs, plus a whopping savings in materials!

Big production savings like these can be yours. A Tinnerman Fastening Analysis on your products may provide the answer... ask the Tinnerman representative in your area for full information on this important engineering service.

No matter what you assemble or build, it will pay you to turn to Tinnerman for better fastening engineering! Write today for your copy of the new "Savings Stories" booklet. TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio.

In Canada: Dominion Fasteners Ltd., Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S.A.—7 rue Henri Barbusse, Levallois (Seine.)


OLD WAY
Instrument panel cluster used 4 T-shaped weld nuts. Poor hole alignment required costly hand filing on production line.
SPEED NUT WAY
Self-retaining "U" type SPEED NUTS snap in place by hand. Float in mounting hole to offset normal tolerances. Eliminate hole misalignment problems and welding operation.
OLD WAY
Tubing and wiring secured with pipe clamps, felt spacers, lockwashers and threaded nuts. Spacers jarred loose in service permitting damage to tubing and wiring.
SPEED NUT WAY
Tubing, conduit, wiring now fastened with vibration-proof Tinnerman SPEED CLAMPS featuring special "U" type SPEED NUT and extruded neoprene cushion. One SPEED CLAMP replaces 4 separate pieces.

Who Is To Blame?

IF ONE WERE TO PASS AN OPEN DOOR and hear remarks such as: "Now wait a minute, first let me say something," or, "What you say really doesn't mean anything, let me tell you," or, "Well I never heard that. It cannot be very important,"—one would know that a sales meeting was going on. The quoted expressions are typical of the extrovert whose outstanding characteristics include a healthy degree of conceit, a refusal to recognize arguments contrary to what is desired and the inclination to be heard first and above all others. These are the necessary qualifications for good salesmanship. And generally speaking the best salesmen are poor students. They are hard to convince because they do not want to be convinced. They want to do all the convincing.

There is an old old saying to the effect that engineers do not have the ability to communicate their ideas to others in a clear manner; they cannot teach. That is a very much one sided statement. There is always the question, "Is he a good teacher or are his students dumb." There is nothing so impossible to teach as the person who does not want to learn.

People who are not engineeringly inclined and who are not educated in the sciences cannot readily understand even its elementary principles. But a scientific or engineering degree is not always essential for a practical understanding of a scientific development. Yet many managers will scorn engineers who attempt to explain significant developments.

Fulton found it almost impossible to make men understand the rudimentary principle that steam under pressure will exert a push on the face of a piston. McCormick had a hard job getting anyone to even consent to listen to his explanation of the operation of the reaper. Even taking something as simple and unmechanical as a safety razor, Gillett had a tough time trying to get bankers to allow him to put on a demonstration. Dozens of similar examples can be cited.

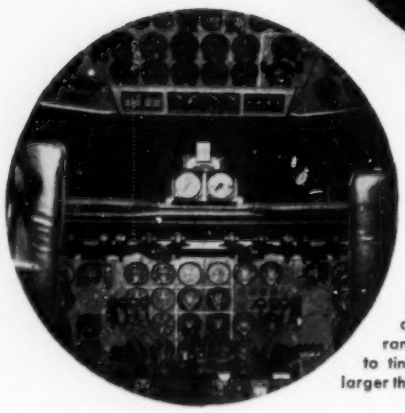
Can it be said that all these great men of science were poor teachers? Did none of these men have the ability to communicate their ideas? The answer is both yes and no. Many of them undoubtedly were good teachers. All of them had a difficult time finding students willing to learn. The greatest hindrance to world progress has not been the inability of the scientists and the engineers to explain their ideas. The hindrance has come from the stupidity and stubbornness of men who wouldn't listen and who did not want to learn.

It often requires a great effort to maintain an open mind. Also, most decisions are based on the emotions rather than logic. By nature, the engineer is a master at logic. The salesman is a master of the art of appealing to the emotions and is usually also an expert in the art of deception.

Who is to be criticized when a company fails to heed the repeated advice of its engineers and thereby loses much money? Shall the engineers be blamed because they had failed to convince management? Or shall management be blamed because management listened with a closed mind and did not want to learn?

Smart management will study seriously the proposals of its engineers even though those proposals have been presented without fanfare, boisterousness or fantastic claims. In other words, the proposals should be studied in spite of the fact that they have been presented clearly, fully and honestly.

George F. Zoldenhoff



New Departure aircraft applications range from turbo-props to tiny pointer pivots no larger than the head of a pin.

Ball Bearings Are Basic

In Sensitive Instrumentation

Moving parts of sensitive instruments call for the extremely accurate, low friction support that only ball bearings can provide. And, whether it's a low torque or high speed application, New Departures meet the most exacting specifications!

Ball bearing production at New Departure is the epitome of precision. Balls for many instrument bearings are ground to within 10-millionths of an inch variation in diameter, and sphericity within 5-millionths! Instrument bearings are assembled, inspected and packed under surgical standards of cleanliness.

Through its resources of research . . . its engineering excellence . . . its precision production . . . New Departure is the recognized leader in the industry. Keep your eye on the BALL to be sure of your BEARINGS!

NOTHING ROLLS LIKE A BALL

NEW DEPARTURE

BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

An Open Door Policy for Inventors

Industry has much to gain by establishing sound working liaison with independent inventors. Crux of the problem is a policy that will protect the interests of all parties. Here are some suggestions.

BENJAMIN MELNITSKY

ALTHOUGH the combined research and engineering facilities of industry, government, and university and commercial institutions have been responsible for the mass development of products and the accumulation of basic knowledge that will provide the foundation for future engineering progress, they have not preempted the function of the inventor.

Engineering and invention are not the same. Each performs an entirely different set of functions. Those for the engineering department have been delineated by these basic objectives:

1. Anticipate and prevent troubles.
2. Cure existing troubles or nuisances; decrease rejects.
3. Reduce the cost of a product.
4. Increase the utility of a product (or utilize waste products.)
5. Reduce operating or maintenance costs.
6. Develop new processes, materials or products.
7. Improve the quality of existing materials or products.
8. Bring about better standardization.
9. Amass technical information leading to a clearer understanding of a product or process.
10. Contribute to the common store of general technical knowledge, with the ultimate motive of increased markets through raised living standards.

Here the individual inventor is out of his element. He is too distant to know of company problems, nor is he sufficiently acquainted with the intricacies of plant operations to suggest solutions.

But engineers' work is too often channeled by the exigencies of day-to-day plant operations; the inventor is a free agent who works uninhibitedly, often to the complete disregard of existing or envisioned industrial needs. In the past, this approach has been responsible for the development of the Diesel engine, monotype, case hardened steel, photogravure, motion picture camera and projector, carbor-

undum, gyro compass, electric auto starter, safety razor, radio crystal detector, airplane, submarine, phenolic plastics, electric precipitation, and many other principles and products. The list goes on and on to include a considerable number of the outstanding 20th Century inventions.

Yet in many respects the inventors' contribution has been glossed over. This is evidenced by the decline in number of inventions from 42 for each 100,000 Americans in 1885 to almost half that number now and, even more graphically, by the manifest difficulty in marketing new ideas.

This decline would hardly be serious were there any certainty that the seller's market could be made a permanent feature of our free enterprise system. As it is, today's sure-fire product may be tomorrow's lemon.

Establishing Proper Relationships

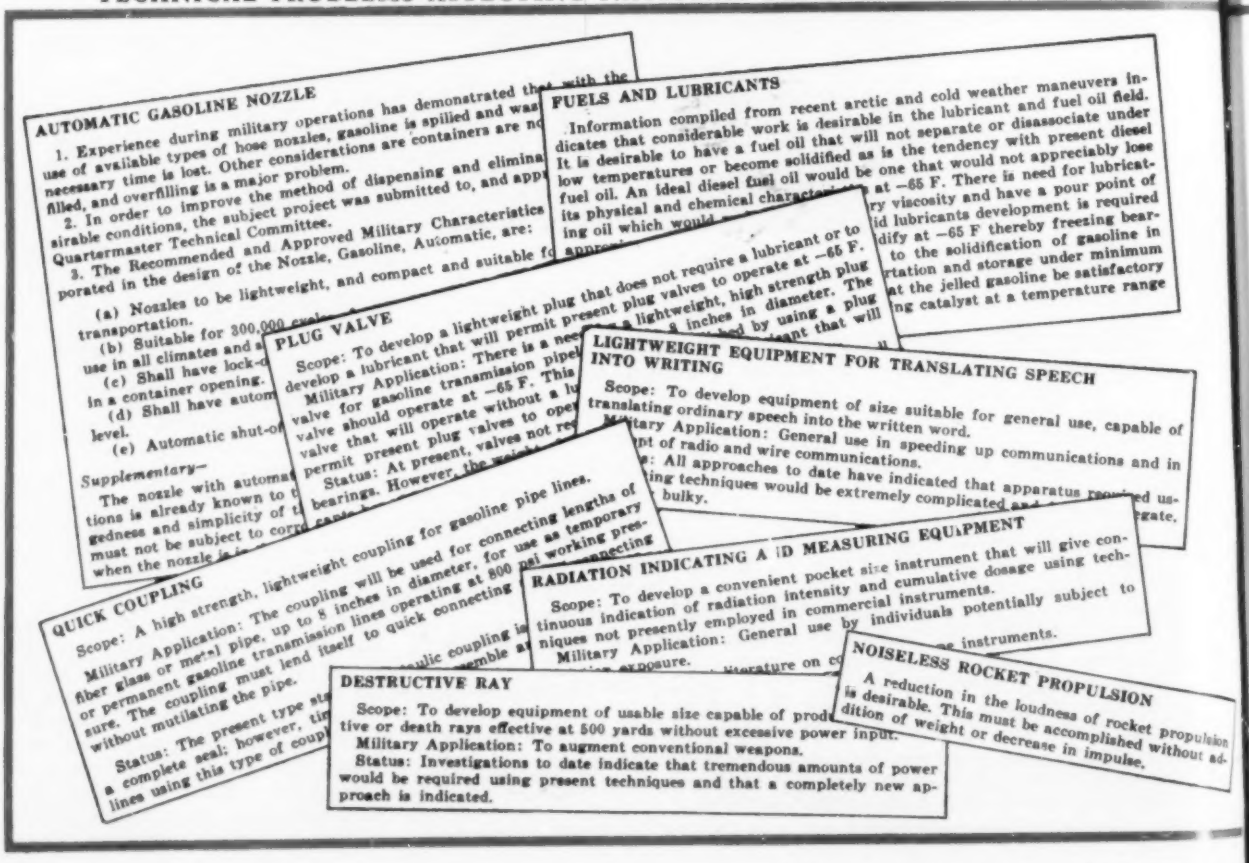
Invention remains an academic subject unless inventors are in the company reception room and programs for considering and utilizing their ideas have been worked out.

On the federal level, the National Inventors Council has since August 6, 1940, provided the machinery for evaluating the ideas of independent inventions for the Armed Services. Also, by publicizing the invention needs of the Armed Services the Council has served a useful liaison function. During world War II over 250,000 suggestions were received and the more promising examined by such experts as Dr. W. D. Coolidge, Dr. Orville Wright, Major General W. H. Tsachappat, and Dr. George Lewis. Of the many military problems submitted to inventors, about 25 percent were solved.

The task of publicizing industry's needs for new inventions is being accomplished to a less satisfactory degree by a diversity of methods. A midwestern machine shop attracts inventors by an obvious expedient; its small advertisements in the business section of the *New York Times* invite the submittal of outside ideas. The National Foundation for Science and Industry in Chicago reverses the procedure and distributes to some 3,200 manufacturers a monthly digest of new inventions. Another variation is the *Inventor's Sales Bulletin* in which manufacturers with facilities that could be used for making new products list their invention needs; the *Bulletin* is sold to inventors by the Science & Mechanics Publishing Company in Chicago. The National Patent Council, Gary, Indiana, describes newly patented products in its bi-monthly *Invention News*. The major source list for new inventions is the *Weekly Official Gazette* published by the U.S. Patent Office. Specifications and drawings for all newly granted patents are found here.

Industry's interests do not dictate flinging open its doors to all and sundry who considered themselves inventors. So doing would entail a tremendous administrative expense and a significant waste of company time. Even more important, such a procedure would certainly lead to legal difficulties, law suits, and consequent bad publicity. For these reasons, the initial step in any program for considering outside ideas takes the form of a letter, mimeographed sheets, or a printed

TECHNICAL PROBLEMS AFFECTING NATIONAL DEFENSE


AUTOMATIC GASOLINE NOZZLE
1. Experience during military operations has demonstrated that with the use of available types of hose nozzles, gasoline is spilled and was necessary time is lost. Other considerations are containers are no filled, and overfilling is a major problem.
2. In order to improve the method of dispensing and elimina sirable conditions, the subject project was submitted to, and app Quartermaster Technical Committee.
3. The Recommended and Approved Military Characteristics porated in the design of the Nozzle, Gasoline, Automatic, are:
(a) Nozzles to be lightweight, and compact and suitable fo transportation.
(b) Suitable for 300,000 cycles
use in all climates and a
(c) Shall have lock-o
in a container opening.
(d) Shall have autom
level.
(e) Automatic shut-o
Supplementary—
The nozzle with automa
tions is already known to t
gedness and simplicity of t
must not be subject to corr
when the nozzle is
FUELS AND LUBRICANTS
Information compiled from recent arctic and cold weather maneuvers indicates that considerable work is desirable in the lubricant and fuel oil field. It is desirable to have a fuel oil that will not separate or disassociate under low temperatures or become solidified as is the tendency with present diesel fuel oil. An ideal diesel fuel oil would be one that would not appreciably lose its physical and chemical
at −65 F. There is need for lubricating oil which would
ry viscosity and have a pour point of
id lubricants development is required
dify at −65 F thereby freezing bear-
to the solidification of gasoline in
rtation and storage under minimum
at the jelled gasoline be satisfactory
ng catalyst at a temperature range
PLUG VALVE
Scope: To develop a lightweight plug that does not require a lubricant or to develop a lubricant that will permit present plug valves to operate at −65 F.
Military Application: There is a
a lightweight, high strength plug
valve for gasoline transmission pipe
a inches in diameter. The
valve should operate at −65 F. This
by using a plug
valve that will operate without a l
nt that will
permit present plug valves to ope
permit present, valves not re
Status: At present, the
bearings. However, the
LIGHTWEIGHT EQUIPMENT FOR TRANSLATING SPEECH INTO WRITING
Scope: To develop equipment of size suitable for general use, capable of translating ordinary speech into the written word.
Military Application: General use in speeding up communications and in
pt of radio and wire communications.
: All approaches to date have indicated that apparatus
ing techniques would be extremely complicated and
bulky.
gate.
QUICK COUPLING
Scope: A high strength, lightweight coupling for gasoline pipe lines.
Military Application: The coupling will be used for connecting lengths of fiber glass or metal pipe, up to 8 inches in diameter, for use as temporary or permanent gasoline transmission lines operating at 800 psi working pressure. The coupling must lend itself to quick connecting without mutilating the pipe.
Status: The present type st
a complete seal; however, ti
lines using this type of coupl
RADIATION INDICATING AND MEASURING EQUIPMENT
Scope: To develop a convenient pocket size instrument that will give continuous indication of radiation intensity and cumulative dosage using techniques not presently employed in commercial instruments.
Military Application: General use by individuals potentially subject to
exposure.
instruments.
DESTRUCTIVE RAY
Scope: To develop equipment of usable size capable of prod
tive or death rays effective at 500 yards without excessive power input.
Military Application: To augment conventional weapons.
Status: Investigations to date indicate that tremendous amounts of power would be required using present techniques and that a completely new approach is indicated.
NOISELESS ROCKET PROPULSION
A reduction in the loudness of rocket propulsion is desirable. This must be accomplished without addition of weight or decrease in impulse.

booklet. These contain statements of policy designed chiefly to prevent misunderstanding and to maintain good will.

In general, these documents contain one section intended to mollify the sensibilities of those whose ideas have been rejected. RCA does it nicely in this fashion:

"Each year Radio Corporation of America receives hundreds of letters from all over the world offering suggestions which the writers hope may be of value. RCA appreciates the confidence in it shown by the writers of these letters.

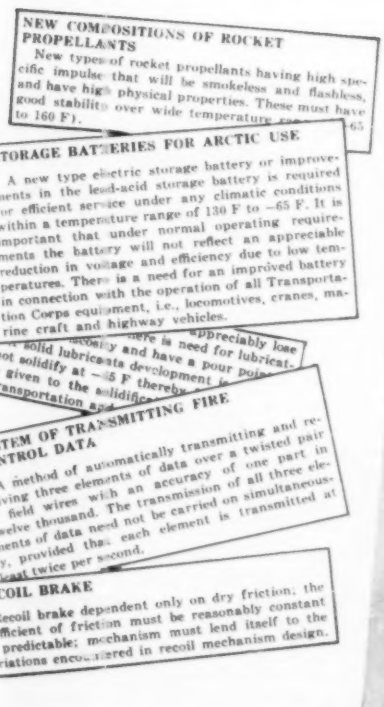
"We realize that, no matter how extensive our research and development activities may be, useful improvements will be made by independent investigators. Consequently, each suggestion is given careful consideration.

"It has been our experience, however, that in most cases no rights can, in fact, be predicted upon the suggestions made by the writers of the letters. This may be due to the fact that an idea is so old as to be freely available for public use, or it may be the subject of a patent, a pending application or an earlier disclosure to someone else. Thus RCA may already have a legal right to use the idea, in which case there can be no actual or implied restriction of this right as a result of the subsequent submission to RCA of a similar idea. In case of doubt as to the respective rights of RCA and an outside inventor, . is the practice of RCA to determine such rights in accordance with the principles of the rules of the U.S. Patent Office applicable to such matters."

It should be recognized that the publication discussed above is as much a public relations document as it is an instrument in dealing with legitimate inventors.

The history of patent litigation invariably proves one fact, namely, the litagee never wins. Where the company sued has been absolved of guilt—this occurs in the vast majority of cases—the publicity resulting from the trial is almost always damaging. Further, patent litigations are tremendously costly to all concerned. Avoiding such legal entanglements is therefore an essential consideration. In this connection, E. I. DuPont notes:

"We prefer to accept a disclosure of an invention only after such an invention is protected by an issued U.S. patent. If a U.S. patent has not been issued, we are sometimes willing to consider a written disclosure if the inventor has taken preliminary steps toward protecting himself under the patent laws, with the written understanding that the inventor is relying and will rely solely upon such patent



NEW COMPOSITIONS OF ROCKET PROPELLANTS

New types of rocket propellants having high specific impulse that will be smokeless and flashless, and have high physical properties. These must have good stability over wide temperature ... to 160 F).

STORAGE BATTERIES FOR ARCTIC USE

A new type electric storage battery or improvements in the lead-acid storage battery is required for efficient service under any climatic conditions within a temperature range of 130 F to −65 F. It is important that under normal operating requirements the battery will not reflect an appreciable reduction in voltage and efficiency due to low temperatures. There is a need for an improved battery in connection with the operation of all Transportation Corps equipment, i.e., locomotives, cranes, marine craft and highway vehicles.

... appreciably lose ... is need for lubricat... and have a pour ... solidify at −65 F thereby ... be given to the solidifica... transportation ...

SYSTEM OF TRANSMITTING FIRE CONTROL DATA

A method of automatically transmitting and receiving three elements of data over a twisted pair of field wires with an accuracy of one part in twelve thousand. The transmission of all three elements of data need not be carried on simultaneously, provided that each element is transmitted at least twice per second.

RECOIL BRAKE

Recoil brake dependent only on dry friction; the coefficient of friction must be reasonably constant or predictable; mechanism must lend itself to the variations encountered in recoil mechanism design.

AN OFFER OF RESEARCH FACILITIES TO INVENTIVE AMERICANS WHO NEED THEM

INVENTIVE Americans are often at a loss today. Not because of any lack of ideas, but because of a need for large and expensive facilities to find out if and how their ideas work.

This was no obstacle in our earlier days. The Wright Brothers designed their first airplane with the help of a foot-square homemade "wind box"—and the plane flew.

In contrast, the man with a new idea in airplane design today often needs a supersonic wind tunnel costing millions.

In short, science and invention have become so complex that a man with an idea for a better product often needs the assistance of an army of specialists and millions worth of equipment to prove his idea has value.

Within the petroleum field, the Sinclair Plan now offers to provide that assistance.

Under this Plan, Sinclair is opening up its great research laboratories at Harvey, Illinois, to independent inventors who have sufficiently good ideas for better petroleum products or for new applications of petroleum products.

If you have an idea of this kind, you are invited to submit it to the Sinclair Research Laboratories, with the provision that each idea must first be protected, in your own interest, by a patent application, or a patent.

The Inventor's Idea Remains His Own Property

If the laboratories select your idea for development, they will make, in most cases, a very simple arrangement with you: In return for the laboratories' investment of time, facilities, money and personnel, Sinclair will receive the privilege of using the idea for its own companies, free from royalties. This in no way hinders the inventor from selling his idea, which was developed under the Sinclair Plan, to any of the hundreds of other oil companies for whatever he can get. Sinclair has *no control* over the inventor's sale of his idea to others, and has *no participation* in any of the inventor's profits through such dealings. Moreover, it is a competitive characteristic of the oil business that the new products adopted by one company are almost invariably adopted by the whole industry. This means that his agreement with Sinclair should open up to the inventor commercial opportunities which might otherwise be hard to find.

How to proceed: Instructions on how to submit ideas under the Sinclair Plan are contained in an Inventor's Booklet available on request. Write to: W. M. Flowers, Executive Vice-President, Sinclair Research Laboratories, Inc., 630 Fifth Avenue, New York 20, N. Y. for your copy.

IMPORTANT: *Please do not send in any ideas until you have sent for and received the instructions.*

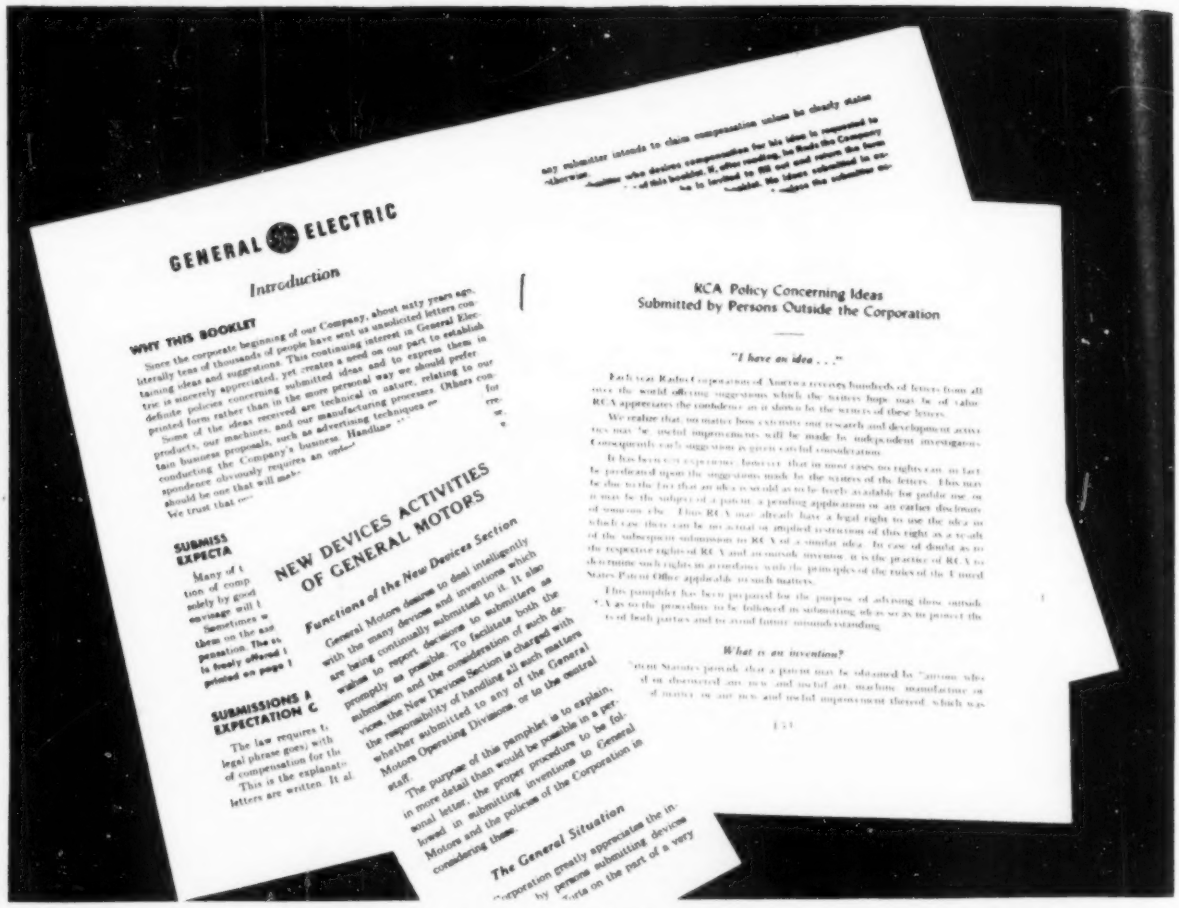

GENERAL ELECTRIC
Introduction
WHY THIS BOOKLET
NEW DEVICES ACTIVITIES OF GENERAL MOTORS
Functions of the New Devices Section
SUBMISSIONS & EXPECTATION C
RCA Policy Concerning Ideas
Submitted by Persons Outside the Corporation
"I have an idea . . ."
What is an invention?
The General Situation

Fig. 2—Industry has established policies and procedures that stimulate fresh ideas that protect the interests of both the company and the inventor. Many large companies have printed booklets that outline the steps when submitting an invention.

rights as he may acquire and also on the understanding that this Company assumes no obligation whatsoever further than advising the inventor whether or not we are interested in acquiring patent rights".

The Standard Oil Company (New Jersey) advises that the inventor "should disclose no information on which he has not already obtained or applied for a patent. . . If steps to obtain patent protection have not been taken and cannot be taken promptly, a written description of the invention may be accepted. This should be dated, signed by the inventor and attested by a notary, who should affix his seal on each page or sheet. A similarly attested copy should be retained by the inventor. The description should give an example of the practical uses of the invention in full detail and should also indicate the particular point which the inventor believes to be novel. If possible, the inventor should state the terms on which he wishes to deal."

The Radio Corporation of America also takes the trouble to stress the need for the inventor to protect himself by listing, in order of preference, procedures to be employed:

1. Consult a patent attorney and obtain a patent. Send a copy of the patent along with your letter.

2. File an application for a patent. Send RCA a copy of the specification, claims and drawings.

3. Reduce the invention to practice by building and successfully operating the device, or practicing the method. Have at least two witnesses who understand the invention witness the operation. Make a complete written description, in duplicate, of the objects and purpose of the invention, describing its construction and operation in detail including whatever drawings or sketches are necessary to understand it. Sign and date one copy of the papers and have them signed and dated by two reliable witnesses who understand the invention. The inventor may then carefully preserve the signed copy and send the unsigned copy to RCA.

4. Make a complete written description and drawings of the invention, have these witnessed and dated as set forth in the paragraph above, and then send RCA a copy."

The next step, after insuring that the inventor has protected himself as fully as possible, is the logical and necessary one of protecting the company. Included here are the following measures which the inventor must agree to prior to submitting his ideas:

1. No device, plan, idea or suggestion may be received "in confidence" and no "confidential relation" may be established with a submitter. (General Motors.)

2. No obligation with respect to any device or design may be entered into which would imply any restriction on company activities that is not provided by the United States Patent Laws. (General Motors)

3. The Company shall be under no obligation to reveal Company activities relating to the subject matter of submitted ideas. (General Electric.)

4. No papers submitted will be returned except in special instances and the Company may make copies. (Standard Oil of New Jersey).

5. The company accepts and con-

siders patentable inventions and unpatentable ideas submitted by the public only upon the understanding that the submission is gratuitous and unsolicited . . . and that it entails no obligation on the part of the company to adopt the suggestion or to make compensation for its use. (Radio Corporation of America).

6. The company makes no commitment that the idea or material submitted shall be kept a secret. (General Electric.)

7. The company will consider the ideas submitted only so far as in its judgment they require consideration; and it assumes no obligation more than to indicate in reply whether or not it is interested. (IBM)

8. The reception and consideration by the company of any submitted disclosure of a patentable idea shall not in any way impair the company's right to contest the validity of any patent that may have been or may thereafter be obtained on it. The submitter's sole remedy if he believes the company to be infringing such patent shall be the enforcement by him under the patent laws of the United States of such exclusive rights as he may possess by virtue of his patent. (General Electric)

9. The foregoing conditions may not be modified or abrogated except in writing agreed to by one of our executives or duly authorized officers. (IBM)

The final element of company protection is a release form from the inventor. It can be argued that the inventor forfeits many rights by signing such a release or agreeing to the rather harsh terms cited above. He does leave himself open to theft should the company be unscrupulous. It goes without saying that ideas are occasionally pirated; however, the vast majority of concerns are as honest in their dealings with inventors as with customers, employees, and suppliers. Killing the goose for the golden eggs is bad business no matter where the analogy is applied.

The release form plus other preliminary documents should serve as the basis for an active file on those inventors whose ideas have merit. Here should be deposited correspondence, newspaper clippings about the inventor, copies of memorandums, records of interviews, and other pertinent material. Each item should be dated, signed, and in some instances countersigned or notarized. Should the inventor bring legal actions against the company, the file will prove invaluable.

The inventor file should also contain information on those inventors who have never submitted ideas and who have never evince the slightest interest in company activities. It is the responsibility of the manager of the patent department in a large manufacturing concern to obtain copies of all new patents which are even remotely connected with the products manufactured by the concern. The purposes of this are to keep the concern posted on new developments, to indicate patents that might be worth purchasing, and to check on patent infringements. An even more important reason is to learn of individual inventors whose work indicates abilities that might be of value to the concern. An active file is set up for each of these inventors and when it is deemed advisable, interviews are arranged.

Those who have had dealings with free lance inventors all know that, as a class, they are difficult persons to do business with—unpredictable and often unreliable in keeping appointments or meeting deadlines. The inventor must be handled tactfully. His demands may often be unreasonable and his disregard for such mundane matters as profit and loss can be most disconcerting.

H. Stafford Hatfield, a noted British scientist has said that "the inventor is a reactor, a stubborn questioner, a rebel. . . . Self will and refusal to be led characterize the person all through." Clearly, this demands that the company representative who negotiates with inventors should be an executive who carries some weight within the organization. Hatfield states further that "inventiveness generally shows itself at an early age." The firm which refuses to consider an idea because its creator is young makes a serious mistake. Philo Farnsworth, George Westinghouse, Thomas Alva Edison, Edwin H. Land, and many other notable inventors were in their teens when granted their first patents.

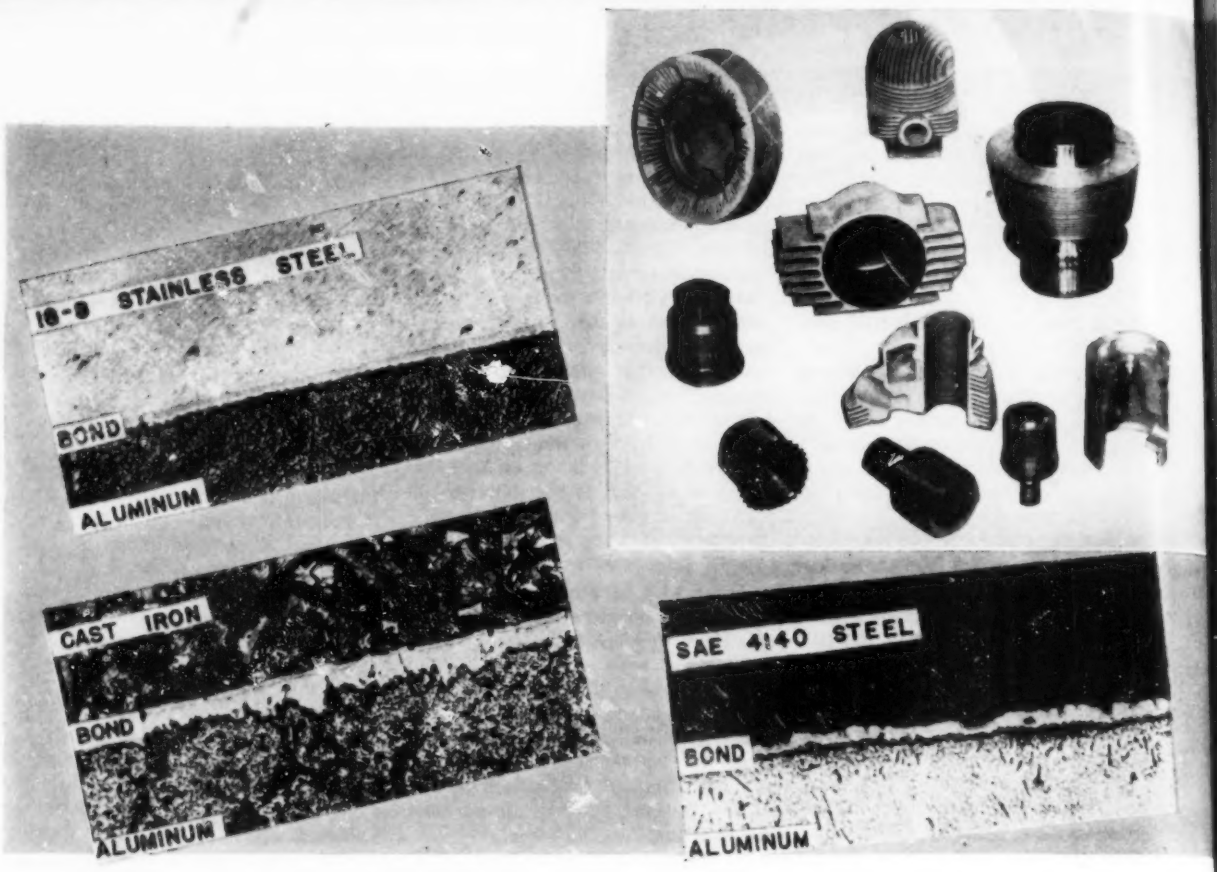
Many a straight-laced executive has been unduly prejudiced against an invention brought into the office by a garishly-dressed individual. Hatfield has some sage counsel here: "The inventor suffers none of those acute pains from breaches of social consideration and convention, from contact with the bizarre or the "not quite nice," which afflict (the ordinary person.") He further specifies that the inventor's sole justification to himself for his own existence rests upon his active pursuit of his life's work. "This accounts for the fact that such types . . . commonly exhibit a disregard for sources of self-feeling which other people seek so eagerly—money, family life, social status, and approbation."

Industry's stake in the invention profession dictates an open mind toward new ideas, a willingness to do business with outside inventors. Self-interest demands even more. The invention profession must be revitalized. The patent system and patent law should be studied by industry and iniquities removed. At the present time a patent invests its owner with little more than the right to sue. One observer notes that the history of most outstanding inventions in the past is the story of the inventor's spending much or most of his profits suing for infringements.

Industry should offer as much direct aid as possible to the inventor. The development of the Prepo blow torch is an excellent example of industry-inventor cooperation. Louis A. Falligant, a young ex-naval officer, hit upon the idea of a portable blow torch with several improved features. His plan was to eliminate hand pumping by use of self-pressurizing fuel carried in a disposable and replaceable container. The Phillips Petroleum Company opened its laboratories to Falligant and developed for him a special liquid petroleum fuel which was self-pressurizing at normal temperatures. The Crown Can Company was equally cooperative. Their research departments spent months with the inventor in eliminating flaws in the product. In both instances the companies provided their services free of charge with no strings attached. Needless to say, the Pressure Products Corporation which Falligant founded in December 1949 purchases its fuel from Phillips and its containers from Crown.

Cooperation with worthwhile inventors takes many other forms as well. Permitting free use of company materials and products for experimental work; granting access to research department equipment; offering engineering advice and counsel to inventors; aiding in the development of working models—these are but some of the low cost measures to be undertaken by industry in its task of restoring the invention profession to the prominence it once enjoyed.

Deep rooted prejudice against change must, in itself, be changed to such an extent that each inventor with a worthwhile idea will receive a fair hearing. This cannot be legislated—such an enlightened approach must spring from the knowledge that invention is vital to business, that tomorrow's free enterprise stems from today's inventions.



Applications Extended for

GREATER UTILIZATION of the Al-Fin process beyond the original heat transfer applications has materialized through extensive study of the bonding process and thorough testing of the bond.

The bimetallic combinations are now developed for applications requiring the hardness, strength and fatigue resistance of ferrous metals and the light weight, high heat conductivity, good bearing properties, and oxidation resistance of aluminum.

Pure aluminum and any of its common casting alloys, such as Alcoa 43, 122, 132, 142, 195, 220, 335, 356, Almag 35, and Frontier 40E, can be bonded successfully to gray, malleable, ductile or nodular and austenitic irons, carbon, alloy, and stainless steels, Inconel, and the Nimonic series and titanium. Bi-metallic units can be heat-treated to improve physical properties and to stress-relieve the aluminum.

The process (Product Engineering, May, 1944) consists basically of applying a coating of aluminum to a metallic surface, usually ferrous, and then casting an aluminum alloy against the coated surface.

The Process

There are three basic steps in the Al-Fin Process: surface preparation and masking of the base metal; dipping the metal part into an aluminum bath to produce the bonded coating; casting an aluminum alloy against the prepared surface.

The surface to be bonded must be free of oxides. Sandblasting, chemical cleaning or a machining operation is necessary to obtain a clean surface. The areas not required to be coated are masked-off by spraying or painting with colloidal graphite. The part is then immersed in molten aluminum at about 1,300 F. The aluminum reacts at the surface of the part to form an intermetallic compound.

The coated part is transferred from the aluminum bath to the mold while the coating is still molten to minimize formation of aluminum oxide and to insure effective fusion of the casting alloy with the coating. In cases where transfer to the mold while the coating is still molten is impracticable, a secondary heating operation may be used to reactivate the surface prior to casting. This can be done by induction heating, oxy-acetylene reducing gas heating or other industrial heating methods.

After transfer of the treated base metal to the casting mold, the aluminum alloy is cast against the part—either by sand casting, pressure casting or die casting. No special technique or equipment is necessary.

The Bimetallic Bond

The Al-Fin Process is classified as one of molecular bonding rather than mechanical joining. Ferrous metals, nickel and titanium react with molten aluminum to form an intermetallic

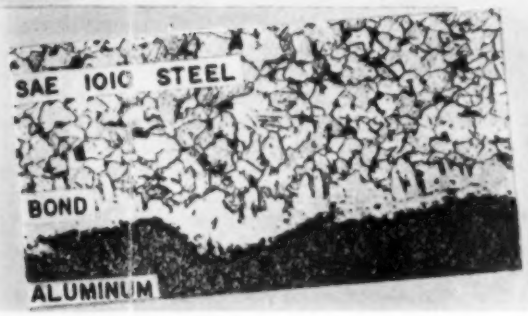


Fig. 1—Aluminum bonded bimetallic units include brake drums, air-cooled cylinders, steel backed aluminum bearings, timing gears, cooking ware piston ring carriers and other functional parts.

Fig. 2—Photomicrographs showing the bonded area of bimetal units. The intermetallic compound that forms during the treating process is clearly visible.

Aluminum Bonding

compound at their surface. This compound forms the bond between aluminum and the base metal. The region in the proximity of the bond is shown in the photo-micrographs in Fig. 2. A cross-section of a coated metal part, prior to casting aluminum against it, will indicate a 0.001 in. film of intermetallic compound bonded to the bare metal, and adhering to the surface of the compound will be a 0.002 in. film of aluminum. It is this film of aluminum that facilitates casting the aluminum alloy against the treated part.

The bond has a mean tensile strength of 15,000 psi and can withstand shearing stresses in the order of 8,000 psi. This strength is retained up to 500 F. The bonded construction withstands vibration and will withstand pressures up to 3,500 psi for hot hydraulic oil and 1,000 psi for dry nitrogen without leaking.

Electrolytic corrosion is not a serious problem with this type bi-metallic construction because there is no direct aluminum to ferrous metal couple. The intermetallic compound acts as a buffer between the two metals. The electrolytic potential between either the base metal or the aluminum alloy and the intermetallic compound is considerably less than that between the base metal and the aluminum. Also there is a gradation of aluminum-base metal alloy at each side of the interface to further reduce the potential.

Applications Numerous

Heat Transfer. The original field of application for this process was for heat transfer in such parts as air-cooled cylinder barrels for aircraft and in commercial heat exchangers. As indicated in Fig. 3 there is no measurable resistance to heat flow across the interface of the aluminum and base metal as would be expected in a mechanically joined sandwich.

Heat transfer applications have been extended in the past few years. Aluminum internal cooling fins bonded to the rotor of an eddy current clutch is one example. In this case advantage is taken of the good electrical conductivity of aluminum and the intermetallic compound as well as their good heat conductivity.

Another application is the exhaust stack heat exchanger used in aircraft engines which consists of an Inconel shell with bonded aluminum fins. Waste heat of the exhaust gas is used to heat large volumes of fresh air for deicing critical wing and empennage sections.

In the manufacture of cooking utensils, the good conductivity of aluminum is used to advantage by bonding $\frac{1}{8}$ inch thick aluminum bottoms to 0.025 in. thick stainless steel pots and pans.

Weight Reduction. Important weight reductions in aircraft and automotive construction have been effected through the intelligent application of this process—without reducing strength and wearing qualities. Steel inserts are bonded to the aluminum at locations where strength or wear resistance is required. This type construction, Fig. 4 (a), is used for aluminum housings with bonded-in steel bearing retainers and oil seal bushings and for aluminum timing gears, with bonded-in steel hubs. These gears have a service life several times that

of commercial molded resin-fiber gears.

The service life of aluminum pistons for heavy duty gasoline and Diesel engines, has been increased by bonding-in a ferrous metal top ring carrier. A tough wear resistant groove is thus provided for the top compression piston ring. This ring absorbs about 80 percent of the wear because it is exposed to the most intense heat, receives the least lubrication and is subject to abrasion by dust and dirt entering the intake.

The bonded-in ferrous ring band Fig. 4(b) reduces wear of the top ring groove, prevents "blow-by," with resultant savings in oil consumption and reduces piston or piston ring breakage and possible engine damage.

An effective construction for connecting hydraulic servo mechanisms with their actuating controls in missile application Fig. 5 consists of a compact lightweight aluminum housing within which is bonded thin-walled stainless steel tubes, pre-formed to follow their required paths. The housing also contains the actuating pistons so that the hydraulic cylinders become integral parts of the unit.

The tubes are bonded into the aluminum with their ends blind. Admission of hydraulic fluid to the chambers that form the hydraulic cylinders is through slots milled into the tubing. Connections to the controls are through drilled holes of the proper cross section into the blind ends of the tubes. Sealing at the control connection is accomplished by the use of O-rings. The molecular bond prevents leakage between the drilled holes and along the outside diameter of the tubes.

Bearing Applications. Steel-backed aluminum exhibits good bearing properties for heavy duty applications, such as in Diesel engines. The steel backing supports the load and the aluminum functions as the bearing surface. Its bearing qualities include: low coefficient of friction, resistance to chemical attack by engine oils, good thermal characteristics, high load carrying capacity, good fatigue properties conformability and imbedability.

A 6 percent tin-aluminum alloy is used for these bearings. Lead-indium overlay can be used to increase resistance to seizure. The use of steel backing for strength allows for fuller utilization of the bearing characteristics of aluminum alloys without the adverse effects of strengthening alloying elements required in solid aluminum bearings.

Bearings and bushings now being made by this process include cap, slipper, thrust and sleeve type.

Cost Reduction. Besides the functional advantages of bonding aluminum to ferrous metals, savings in production and assembly costs can frequently be obtained. For example, an automotive oil filter container formerly of a multiple component bolted construction, is now made in one piece with the aluminum cap bonded integrally to a steel tube.

Savings were obtained with this process in the manufacture of jet engine compressor stator blades. These blades formerly made of forged aluminum, are now made by bonding rolled steel airfoil sections to a pressure die cast aluminum footing. The root end of the steel strip is prebonded by the Al-Fin process. At the die casting machine the end is induction heated to melt the aluminum on its surface just prior to being inserted in the die cavity. Total savings of about 60 percent were realized through the use of a less expensive blade material, die casting the footings and the elimination of subsequent machining. Tolerances are held to 0.002 inches.

Design of Parts

For high temperature applications, parts must be designed to keep the stresses below the service bond strength values of 15,000 psi for tension and 8,000 psi for shear at the maximum operating temperature of the bimetallic assembly. Apart from applied mechanical loads, bimetallic units, such as brake drums and cylinder barrels, are subjected to heat stresses which are direct functions of the difference in thermal coefficients of expansion of the component members, weight and volume ratios of these members, and the dimensional complexities of the individual designs.

Three important considerations for designing bimetallic units to compensate for high thermal stresses are:

1. Design the bimetallic unit so that one member, the ferrous part or the aluminum part, has thickness and length ratios to allow elastic deformation during heating and cooling. Examples of such design are the air-cooled bimetallic cylinder barrel and the bimetallic stainless steel, aluminum-bottomed cooking utensils. Bimetallic cylinder barrels are made by bonding and casting a rather large mass of commercially pure aluminum to the ferrous liner. From a temperature versus thickness failure curve it can be determined that if a standard aircraft engine cylinder barrel with permanent mold unfinned aluminum muff were heated to a temperature of the order of 500 F, the aluminum would tend to separate from the barrel liner. However, this is not the case after the fins are machined. In its final form the layer of aluminum at the base of the fins has a thickness of the order of $\frac{1}{16}$ in. The fin pitch for optimum heat transfer is 0.100 in. and the fin thickness is 0.030 in. In other words, the space between the fins represented 70 percent of the total volume of aluminum cast. Since the fins are actually thin disks of aluminum, they act in an elastic-unstable fashion when stressed and no longer follow directly the moment of inertia equation in which stiffness is a function of the third power of fin height (radial depth). After machining the aluminum fins, the same bimetallic cylinder barrel could be heated to the melting point of aluminum without rupturing the bond.

Study of an Al-Fin bimetallic cooking utensil will show that as a structural member it is quite elastic since the stainless steel portion is 0.025 in. thick and the bonded aluminum bottom is $\frac{1}{8}$ in. thick. Thus it can be compared somewhat to a bimetallic thermostat construction in which the ends (although of circular construction) are free to move. For such a construction the bond stress is dependent upon three main functions, namely: modulus of elasticity, difference in temperature expansion coefficients, and operating temperature. A very important factor in this construction is the lowering of the modulus of elasticity of aluminum with temperature which results in a direct reduction of the bond stress.

2. Another design procedure is to make use of high thermal expansion type ferrous metals, such as high nickel cast iron known as "Ni-Resist" type I. The thermal coefficient of expansion of this material is comparable with any of the commercial aluminum alloys and for a temperature range of 70 F to 400 F is within a 5 to 10 percent range lower than the commercial piston aluminum alloy A-132. Since the bond stresses are a direct function of the difference in coefficients of thermal expansion is can be seen that with these two materials the bond shear stresses would be moderate even at relatively high temperatures. An excellent service proven example of this type of design is the well known Al-Fin bimetallic piston of aluminum with bonded-in ferrous ring carrier.

3. Still another design procedure is to use a low strength high ductility aluminum or aluminum alloy so that it offers less restraint during high temperature operation. This third method allows a choice of ferrous members since the aluminum portion, because of its low strength characteristics, would

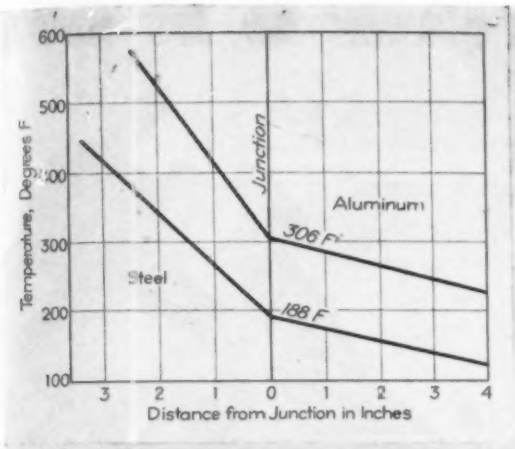


Fig. 3—Heat transfer measurements through the Al-Fin bond indicate no measurable drop in temperature across the interface.

Fig. 5—Top view of a hydraulic manifold base containing stainless steel tubing bonded into a light-weight aluminum housing. This type construction is used to connect hydraulic servo mechanisms with their actuating controls in missile applications.

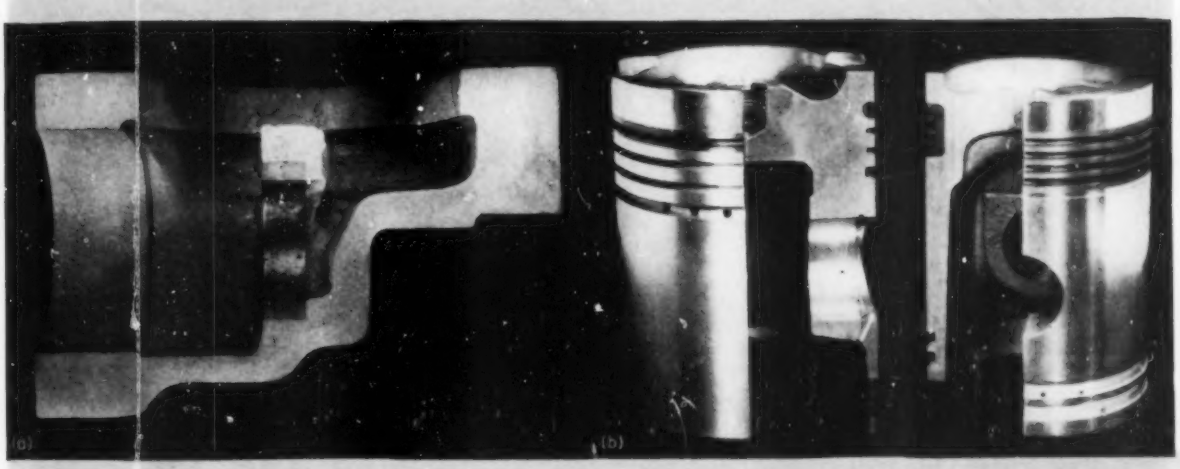


Fig. 4—(a) Steel-backed aluminum, firmly bonded, is used to combine strength and light weight for such applications as aluminum housings with steel bearings. (b) A bonded-in ferrous metal ring carrier for aluminum pistons provides a tough, wear resistant groove for the top piston ring and increases the service life of the pistons.

be too weak to carry heavy loads. This type of construction would be more suitable for non-mechanically loaded parts such as heat exchangers where mechanical strength is secondary.

The considerations presented above also hold true for bimetallic units in which the ferrous member is on the outside and the aluminum is bonded and cast to the inner surface. Here there is the additional problem of the aluminum shrinking away from the steel component while the unit is cooling to room temperature after casting. This creates tensile bond stresses as contrasted to helpful compressive stresses as in applications in which aluminum is on the outside of a ferrous liner. This particular problem is quite important with parts such as steel-backed aluminum-lined bearings. For economic reasons it is advantageous to use inexpensive low carbon steel for the backing material and because the latter has a low coefficient of thermal expansion as compared to the 6 percent tin-aluminum bearing alloy the close expansion differential mentioned above no longer exists. To compensate for the stresses set up during the cooling stage an opposite restraining force must be imposed on the aluminum as it cools from the molten state to room temperature. This is accomplished by the use of a steel core.

In applications that require high strength heat treated steel members it is essential that the physical properties of the steel do not change materially during the Al-Fin processing. Since the bonding temperatures are high enough to partially draw low carbon steels, the more metallurgically stable alloy steels such as SAE 4130, 4340 and Timken 1722 A(S) are recommended. Tests indicate that the fatigue properties of these steels are not materially affected.

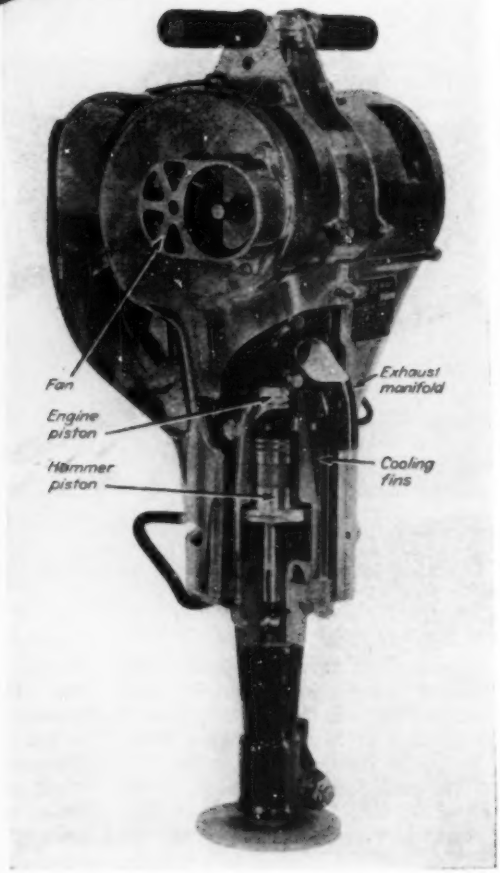
Acknowledgment: Information in this article furnished by Al-Fin Division of Fairchild Engine and Airplane Corporation.

Engine Piston Drives Road Breaker Tool

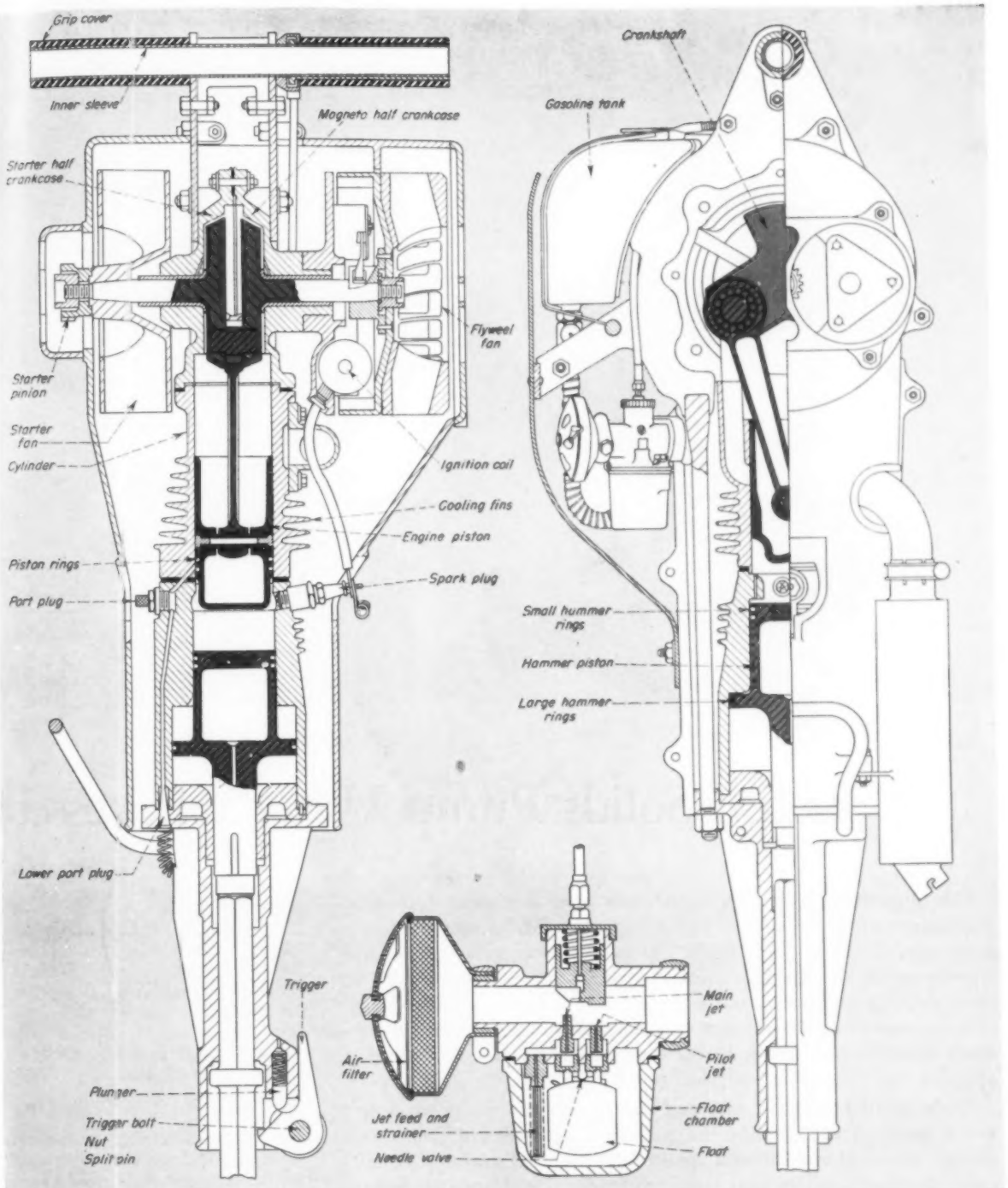
Instead of using compressed air for operation, a new line of road breakers made by Warsop Power Tools Ltd., London, England, has the breaking tool coupled directly to a small gasoline engine. In effect, the power plant is a single cylinder, two cycle opposed-piston type engine and the tool is connected to one of the pistons. The hammer piston that drives the tool is free floating: driven downward by the explosion of the gasoline mixture in the combustion chamber, and returned to striking position by the exhaust gases working on a large diameter section on the underside of the piston.

The exhaust port is located so that some of the gases are retained to provide a cushion at the top and bottom of the stroke and prevent metal-to-metal contact between the hammer piston and the piece that seals off the lower end of the hammer cylinder.

Advantages claimed for this type of equipment include increased portability and reduced operating costs. The breaker consumes about 2¼ gallons of fuel per hr. U. S. distributor for these tools is Warsop Power Tools Inc., P. O. Box 1809, Wilmington 99, Del.

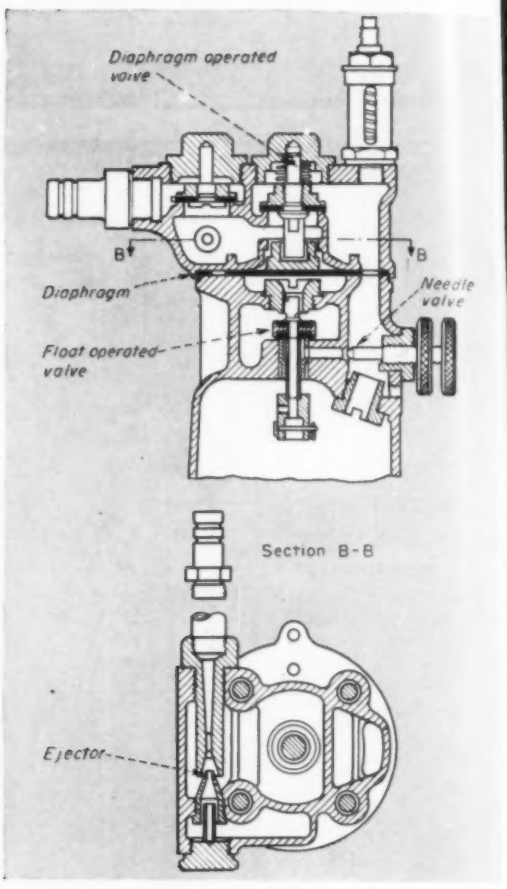


POWERED BY self-contained two-cycle gasoline engine, portable road breaker uses flywheel magneto and ignition coil. Lubrication is obtained by mixing one part oil with 16 parts gasoline when mixture passes through crankcase. Two light alloy fans mounted at each end of crankshaft circulate cooling air around cylinders.



ENGINE UNIT is mounted at head of machine in an inverted positon. Instead of the normal cylinder head there is a hammer unit composed of another cylinder and a piston of two diameters. Chuck or tool holder is located at the lower end of the hammer unit. Entire Assembly is bolted together by draw bolts that pass from the tool holder to the crankcase.

HOW IT WORKS: Explosive mixture is drawn in from carburetor to the crankcase and then to combustion chamber. Spark plug ignites mixture and explosion occurs between engine piston and hammer piston driving engine piston upward and hammer piston downward. Exhaust gases pass through hammer cylinder port to underside of hammer piston and returns piston to striking position.



British Solids Pump Uses Compressed

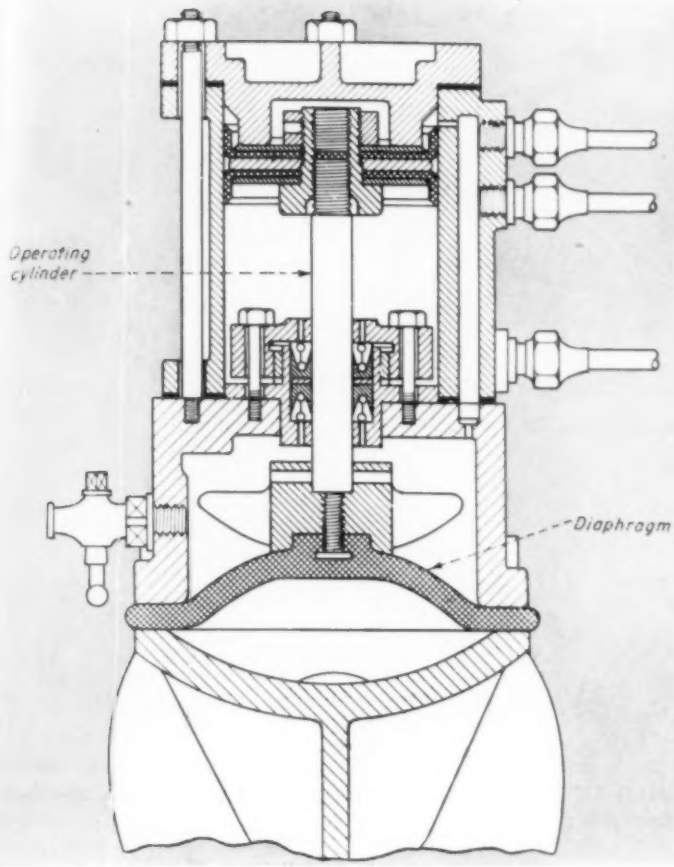
This compressed air-operated displacement pump uses piston operated diaphragm suction and delivery valves to pump solids or semi-solids in suspension. Called the "Ejectopump", it operates on a regular cycle with separate suction and discharge strokes so that it produces a delivery similar to that of a single acting ram pump. A needle valve in the header permits the adjustment of the rate of air admission to the casing during delivery stroke so that output can be controlled to produce the desired pumping rate. The unit is self priming.

The standard pump has a mild steel casing with gunmetal or cast iron valves, gunmetal float and float rod, and cast iron header with gunmetal fittings. For food and chemical applications, the header is supplied in monel metal with stainless steel valves and fittings. Diaphragms are made of synthetic rubber.

Ejectopump is made by Gresham and Craven Ltd, Manchester, England, and is distributed by the Ferro Corporation, Cleveland. The pumps are available in sizes with capacities from 4000 to 9000 g.p.h. With the standard ejector, the pump can work against a 10 ft. intake head and a special ejector is available for a 20 ft. head.

SUCTION STROKE. With the float (F) in lowered position, compressed air passes above float, valve to ejector, holding open valve (B). Compressed air also acts as shown to close delivery valve and open suction valve. Vacuum caused by ejector draws out air in float chamber and draws liquid into chamber.

DELIVERY STROKE. As float rises with fluid it closes float valve to cut off the compressed air supply to the ejector and delivery valves. Instead, air flows through needle valve to close suction and open delivery valves. Compressed air also enters casing to force fluid out. As liquid flows out, float drops closing float valve to start suction stroke again.

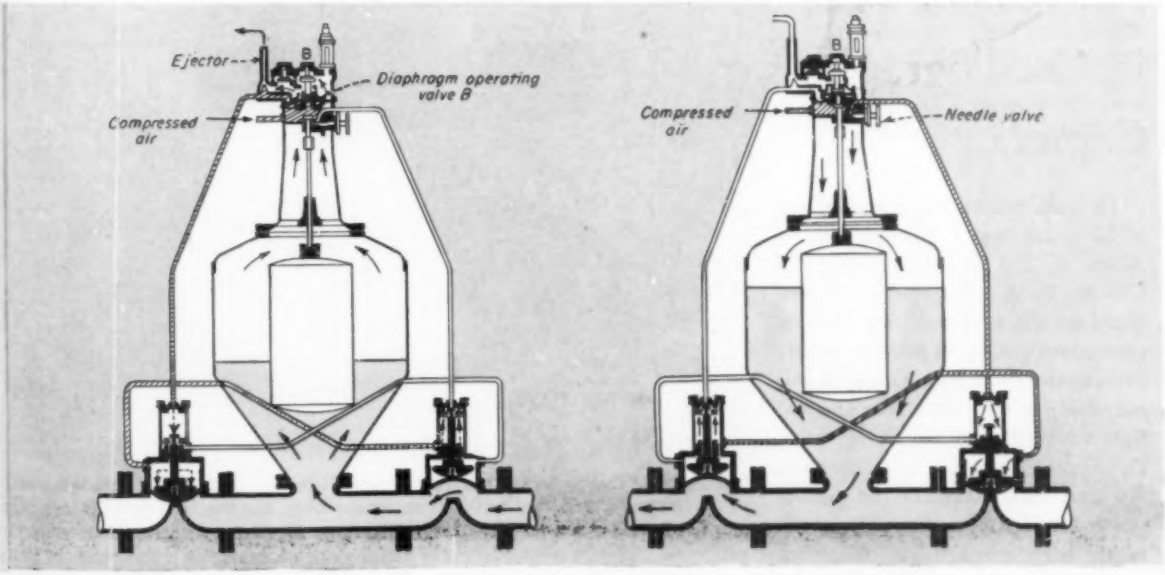


COMPRESSED air-operated displacement pump (far left) consists of cylindrical casing containing a float, a header with air ejector and necessary pneumatic valves, and a manifold to which are attached diaphragm type suction and delivery valves.

CROSS-SECTION of header (center) shows details of ejector. During delivery (as shown) diaphragm and float operated valves are closed so that compressed air flows through needle valve to pump casing and suction and delivery valves.

CROSS-SECTION of delivery valve in the open position. Valve is held open by compressed air acting on under side of operating cylinder. Valve is held closed by compressed air operating on top side of both operating cylinder and diaphragm.

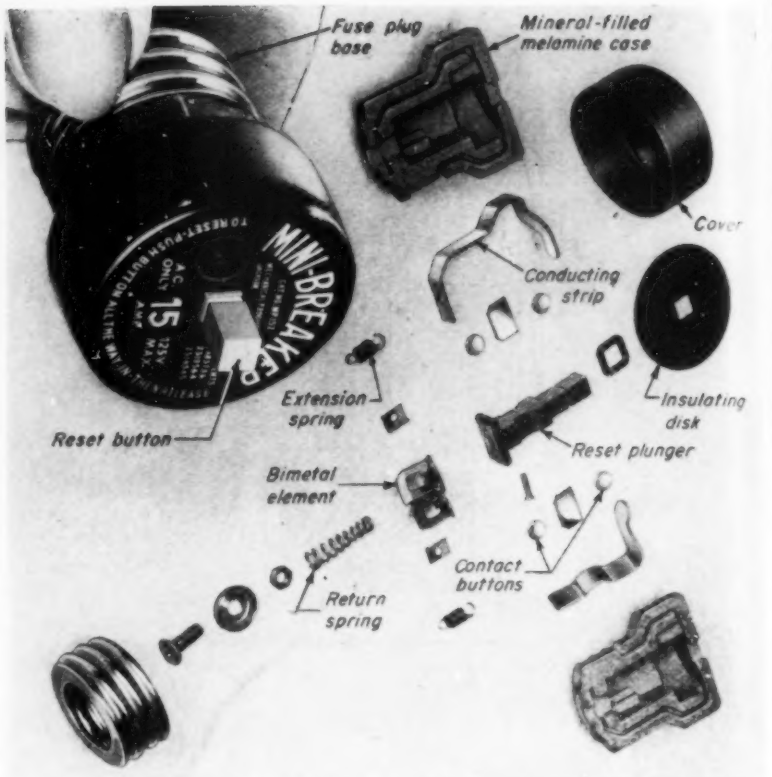
Air and Diaphragm Valves



Bimetal Yoke Trips Miniature Circuit Breaker

When a bimetallic yoke overheats, it expands and releases a spring-loaded mechanism that opens the circuit in a new miniature circuit breaker made by Mechanical Products, Jackson, Mich. After the bimetal is cooled, the circuit can be reclosed by pushing a reset button. Called the "Mini-Breaker" the device has passed Underwriter Laboratory tests in the classification of Circuit Breaker, Miscellaneous.

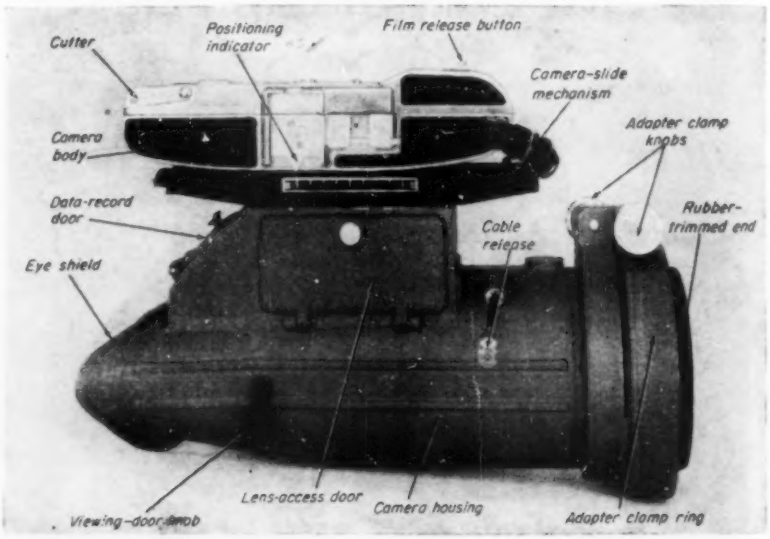
Designed for ordinary residential, commercial, and industrial service, the device meets the temperature conditions required for approval for aircraft use. Characteristics of the breaker permit it to trip at 200 percent load within 120 sec, trip at 125 percent of load within one hour, and interrupt 5,000 amp circuit, 125 v ac, 60 cycles at 50 percent power factor.



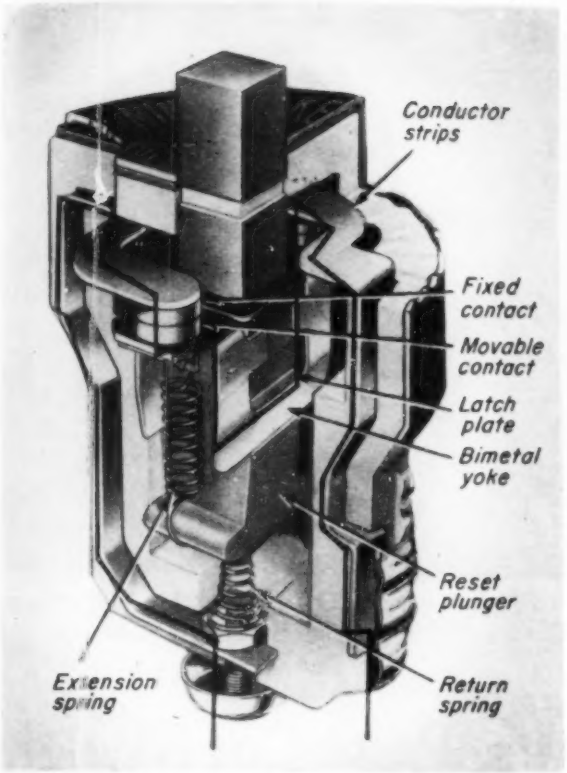
DESIGNED TO FIT an ordinary Edison plug type fuse holder, this thermal circuit breaker is suitable for 15, 20, and 30 amp circuits, 115-125 v. Composed of 25 parts, there are only two moving sub-assemblies: The reset plunger operated by the return springs, and the movable contacts and bimetal activated by the extension spring.

Fold Light Path in Oscillograph Camera

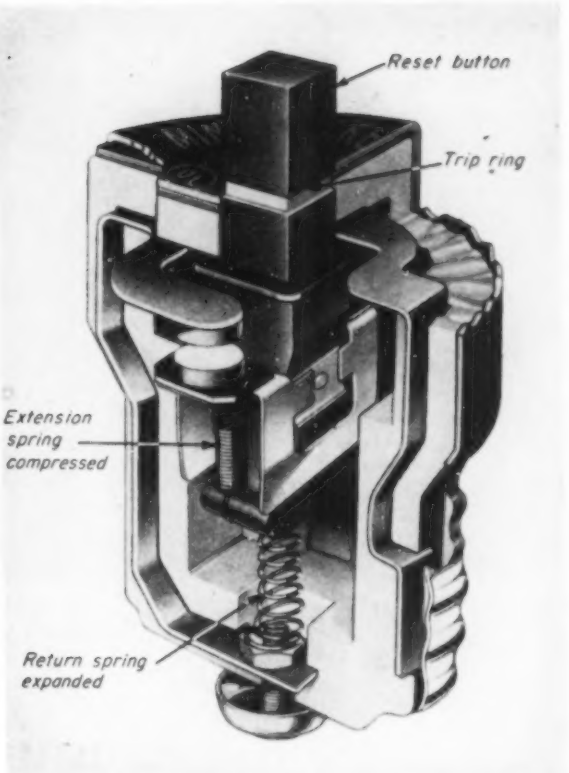
To make permanent recordings of oscillograph wave forms quickly, Allen B. Du Mont Laboratories, Clifton, N. J. developed a camera that uses the Polaroid-Land process to produce a finished print in 60 sec. Because the Polaroid emulsion is not too sensitive to the narrow spectral light emitted by a cathode ray tube, Du Mont employs a wide aperture fl.9 lens so the camera can photograph all oscillographic phenomena except high speed single transients.



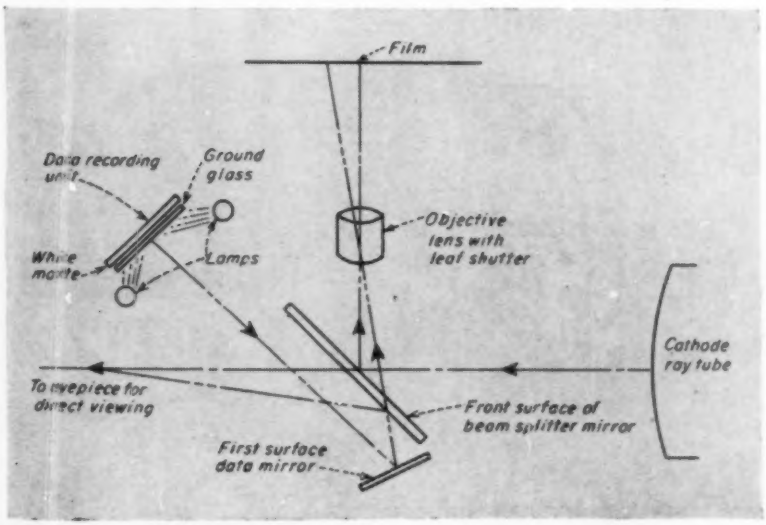
GROUND GLASS writing surface permits entering identifying data on oscillograph record made by Du Mont camera. With sliding film holder, nine low amplitude traces can be photographed on one film for comparative or economic purposes. Adapter allows access to oscilloscope controls while camera is in place.



UNDER NORMAL OPERATING CONDITIONS current flows as indicated. On short or overload, bimetal heats up and bends away from latch plates so that return spring can force plunger outward. Twin extension springs then pull bimetallic element and movable contacts away.



IN THE TRIPPED POSITION, reset button protrudes to expose trip ring. When bimetal has cooled, breaker is reset by pushing plunger down so that latching plates engage bimetallic element. This brings the contacts together, closes the circuit, and preloads the return spring.



BEAM-SPLITTING MIRROR folds light path by sending useful photographic light to the wide aperture lens which can photograph a CR spot moving at a speed of two in. per microsecond. Mirror passes yellow light to eyepiece so operator can view scope while making a photographic record.

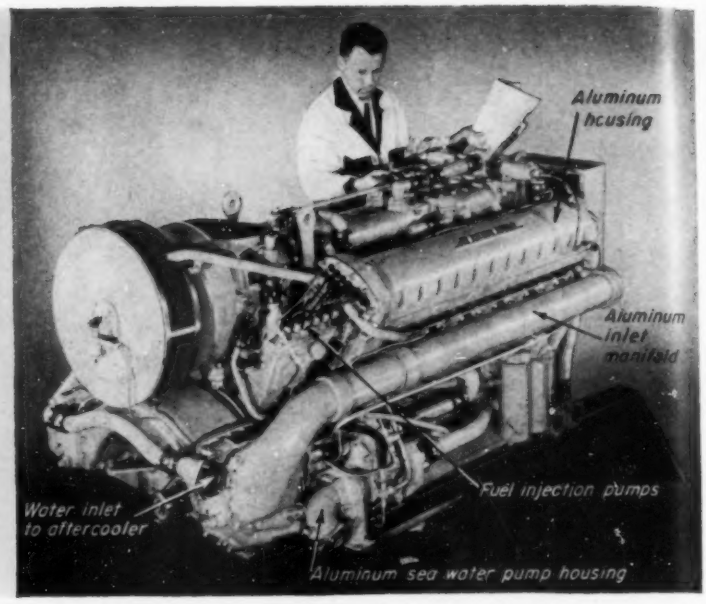
HEART OF THE CAMERA is the folded light path that reduces the length of the camera. A color selective mirror, coated with $\frac{1}{4}$ wave length layers of materials, reflects photographically useful light from the CR tube to the lens and film while it passes the yellow component of light to the eyepiece for direct viewing of the oscillograph.

An aluminum adapter ring mounts the camera to the instrument and grounds the all-metal camera to prevent film fogging by electrostatic charges. The shortened body, and locating the Polaroid film holder on top of the camera lessens the turning moment on the camera-oscillograph joint, and simplifies the problem of securing the camera to the instrument.

Built-in illuminated ground glass surface is arranged so that identifying data like index number or title written on the glass appears at the top of the oscillogram.

Packard reduces engine weight by using aluminum instead of steel parts. Diesels of this rating usually weigh over 7,000 lb; Packard's 600 hp engine weighs only 3,200 lb.

MAJOR ALUMINUM PARTS	MAJOR STEEL PARTS
Crankcase and cylinder barrel	Cylinder liners and heads
Oil pan	Connecting rods
Accessory gear case	Crankshaft
Flywheel housing	Camshaft
Intake manifolds	Valves
Exhaust manifolds	Gear train
Supercharger housings	
Cam shaft housings	
Oil pump housing	
Fresh water pump housing	
Starting motor housing	
Pistons	
Crankshaft bearing cap	



LIGHTWEIGHT, small volume, 12 cylinder diesel has the lowest specific weight of any diesel engine in production: 5.41 lb per bhp.

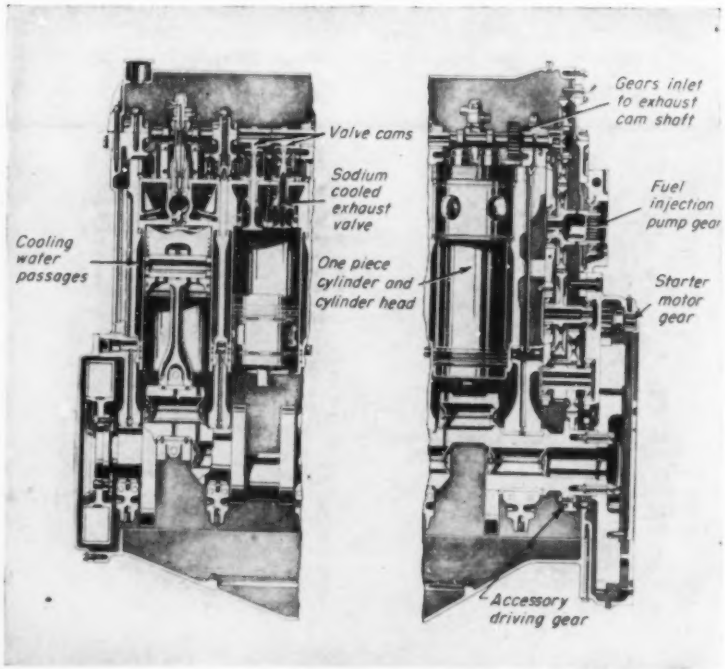
Aluminum Parts Cut Weight

Aluminum castings and forgings replace conventional cast iron and steel parts in a family of new lightweight marine diesel engines developed by the Packard Motor Company for the U. S. Navy. Basic members of the family are a six cylinder, in-line, 300 hp engine weighing 2,200 lb; and V-12, 600 hp engine weighing 3,200 lb.

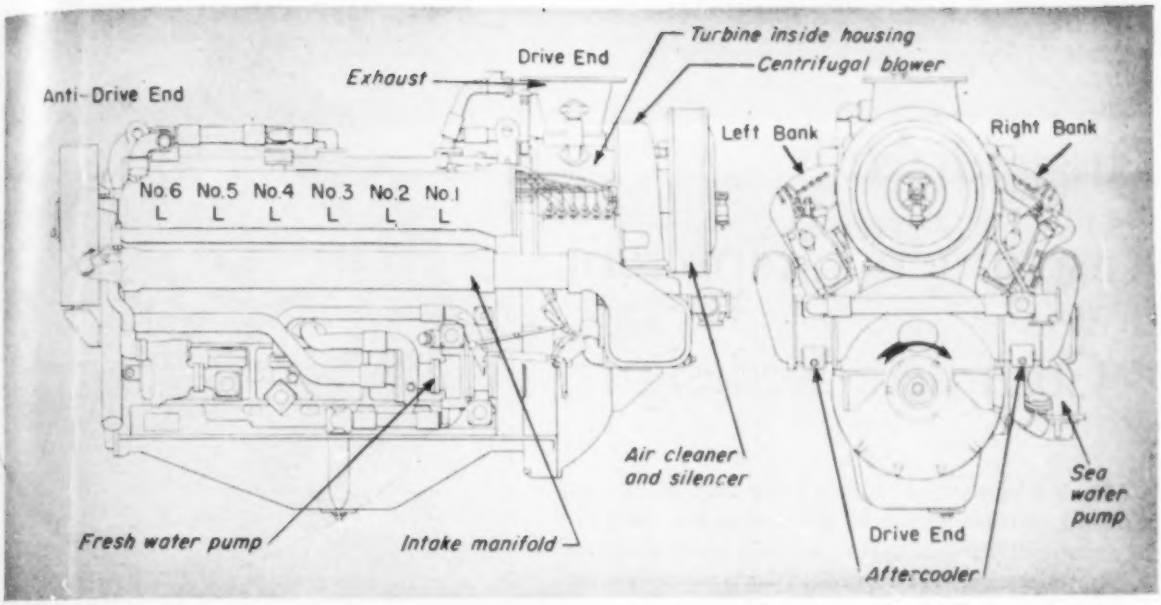
In designing these engines, Packard used a basic standardized cylinder assembly so that most major parts are interchangeable in both engines. Typical parts common to both models: cylinder head and liner assembly, pistons, wrist pins, intake and exhaust valves, valve springs, valve guides, and main and crankshaft bearings. In addition fuel injectors and multiplunger fuel pumps are interchangeable.

Exhaust gases flow through water-jacketed exhaust manifolds to a turbine end of a supercharger where they power a centrifugal blower that draws air through a cleaner.

The engine is fresh-water cooled, using sea water heat exchangers. Circulation keeps outer surfaces cool to the touch.

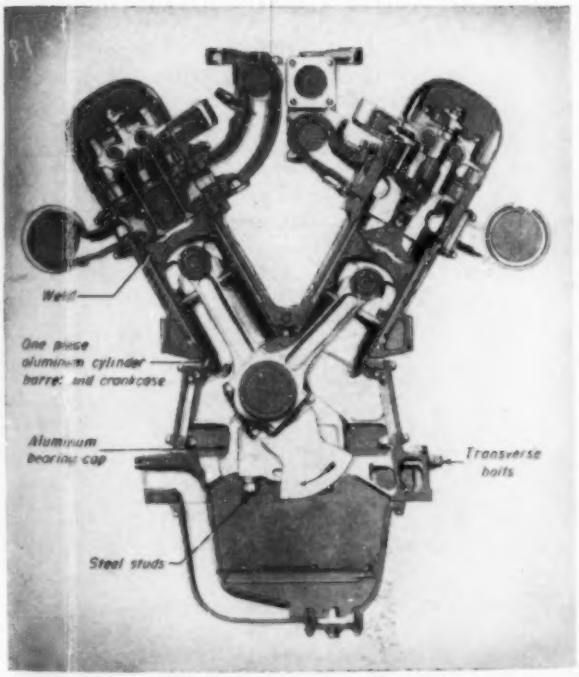


REMOVABLE CYLINDER HEADS are alloy-steel precisions castings and fit within bores at the top of the block. Wet-type cylinder liners are welded to the heads to make a one piece assembly without gaskets. Head is fitted with four valves, two intake and two exhaust, operated directly by cams to eliminate rocker arms.

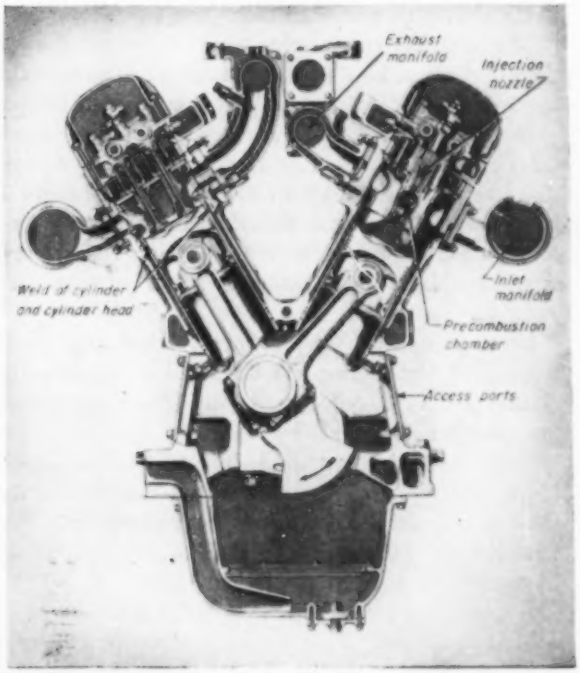


ENGINE EXHAUST GASES run gas turbine supercharger at 39,000 rpm. Centrifugal blower draws air in through cleaner and silencer, and delivers it to aftercooler and then to intake manifold at pressure of 47 in. of mercury.

in Family of Marine Diesel Engines



CRANKCASE and cylinder barrel are one piece aluminum casting to eliminate gasket between engine block and crankcase. Bearing cap is aluminum forging that fits into slotted portion of crankcase. Steel studs hold it in the vertical direction and bolts hold it transversely.



COMBUSTION CHAMBER employs a spherical pre-combustion chamber, precision cast in the alloy-steel cylinder head. Located over center of piston, it ejects hot gases onto the dome of piston. Dispersing cone on piston causes high-velocity jet to mushroom for high turbulence.

Ruggedized Instruments Represent Complete Redesign

Electrical instruments to meet heavy duty military and civilian requirements must be designed so that every part of these usually fragile devices can take heavy shock and constant vibration. The ruggedized instruments described here were developed by the Marion Electrical Instrument Company, Manchester, N. H., in a program initiated by the Squiers Signal Laboratories, U. S. Army Signal Corps, Ft. Monmouth, N. J., and meet JAN-I-6 standards.

First step was the development of a suitable rubber shock mount that has good low temperature characteristics, high dielectric strength, bonds well to steel, will not age or check to any appreciable degree, and does not promote corrosion in a hermetically sealed enclosure or when exposed to high temperatures.

The basic D'Arsonval type of DC movement was redesigned to reduce its mass through the use of a smaller moving system and smaller and lighter magnet and polepieces.

Damage to conventional stamped foil pointer assemblies from shock or vibration as a result of collisions with the dial face is prevented by the use of 52SH aluminum alloy tubing with a minimum flatted section. While a positive lock on the balance cross of the moving system prevents separation from the instrument cross members at the junction.

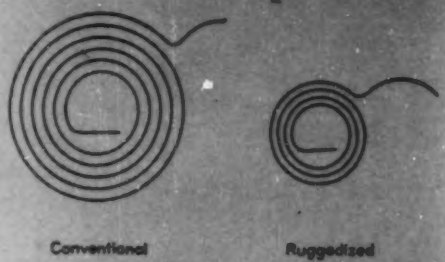
Bearings are also vulernable to shock damage so these ruggedized instruments use large radius, osmium tipped elgiloy pivots that reduce unit loading and hard boro-silicate glass jewels.

Other material substitutions for improved strength and shock resistance include stainless steel machine screws instead of brass screws to increase shear strength, and beryllium copper hair springs replacing those of phosphor bronze.

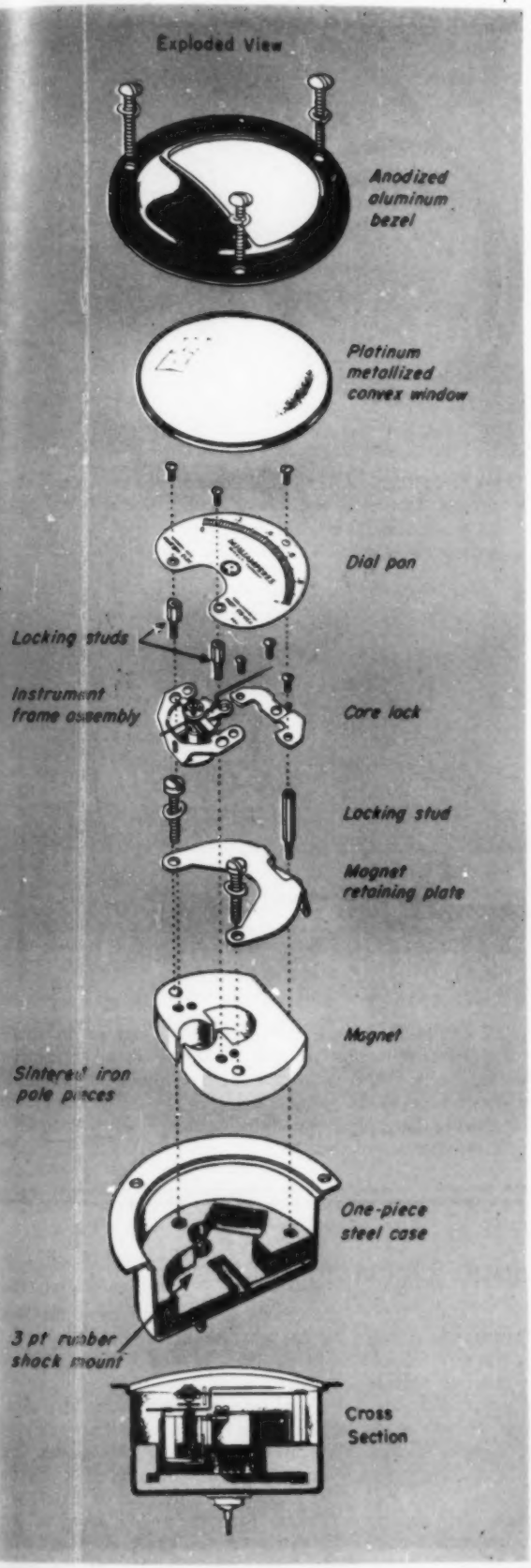
Editor's Note: While the instrument described here has not received Signal Corps qualification approval under specifications Mil-M-10304 Sig C, the Corps has granted a temporary waiver for their use in military equipment. Development of ruggedized instruments is a continuing process. In a forthcoming issue, Product Engineering will describe other newly developed ruggedized instruments.

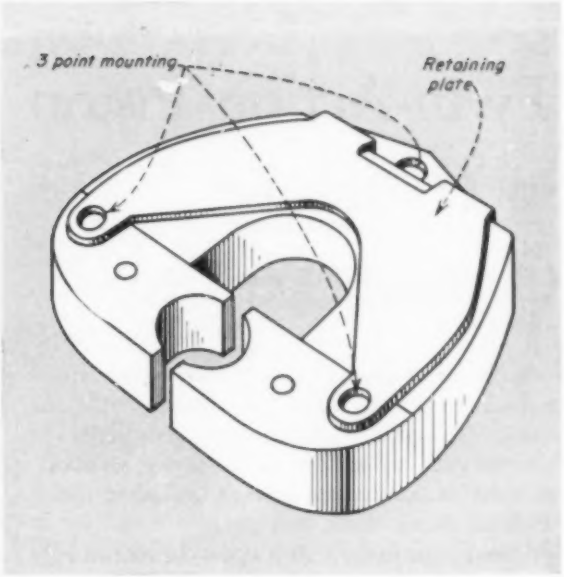
RUGGEDIZED INSTRUMENTS are designed to stand heavy shock and vibration under a wide range of temperature conditions. The window, convex-shaped to increase resistance to shattering, is soldered to the aluminum frame to provide the hermetic seal which makes the unit weather resistant and immersion-proof.

EXPLODED VIEW (right) of ruggedized instrument shows relationship of the specially designed units. Major design changes involve: (1) rubber shock mounts; (2) D'Arsonval movement; (3) magnet retaining plate; (4) frame structure; and (5) pointer assembly. Note that 3 point mounting is used throughout the meter for increased sturdiness and resistance to shock.

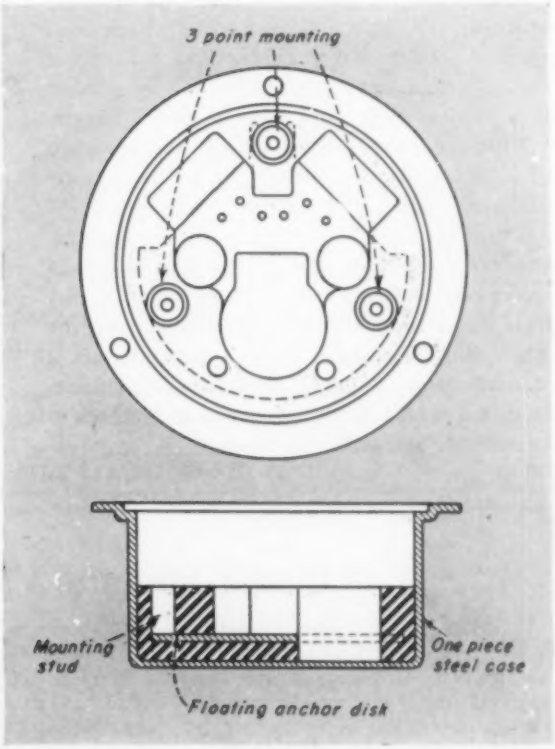


HAIR SPRINGS. Silver coated beryllium copper springs replace phosphor bronze to reduce deformation and zero shift. Springs have the shortest total length, smallest OD and highest natural frequency, consistent with the torque desired.





MAGNET RETAINING PLATE permits distribution of shock forces over large surface of the magnet. Three point mounting minimizes torsional forces. Stainless steel machine screws replace brass to increase shear resistance.



SHOCK MOUNT. A rubber compound of 45 durometer hardness is molded directly to interior of case. Floating anchor disk and three point mounting stud assembly is molded in the center of the rubber block in sandwich form to provide spring-like action under heavy impact and shock.

Twin-Action Piston in Hydraulic Control Actuator

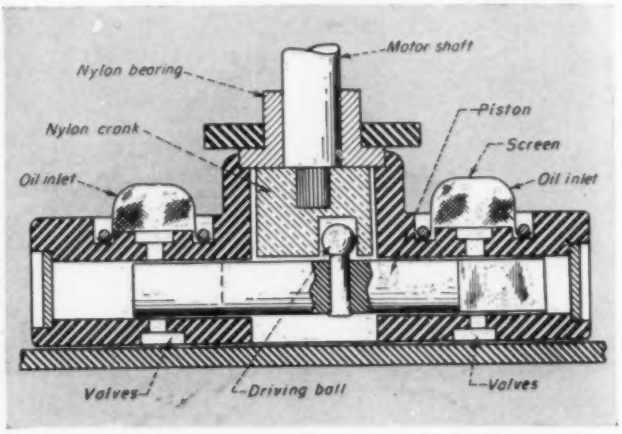
In this on-off control actuator made by the Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a piston pump, whose piston reciprocates for pumping and rotates for valving, supplies pressure for moving the controls instead of conventional motor, worm, and gears.

A thermostat in the system opens the control by supplying electric power to the motor that drives the pump so that the pump supplies oil under pressure to a diaphragm that moves the operating arm. There is no relief valve. The unit continues to run as long as the thermostat supplies electric current to the motor. When the control has run to the open position, the motor stalls or continues running only at a speed sufficient to supply the leakage of the system and to hold a check valve open. The motor does not have sufficient torque to build up a pressure that could rupture the diaphragm.

When the motor stops, the pump pressure drops off allowing a check valve spring to close the check valve and open the return ports.

One of the main advantages of a hydraulic actuator over a worm and gear is more positive protection in case of power failure. If the failure occurs while the actuator is holding the device open, the return effort required to back up the gear train is relatively large. But with the hydraulic actuator, the spring loaded diaphragm forces the oil back to the reservoir and closes the device.

ON-OFF CONTROL ACTUATOR for furnace damper is electrically driven double acting piston pump instead of usual motor and gear train. Driving motor is controlled by a thermostat located in the system. Unit requires no lubrication.



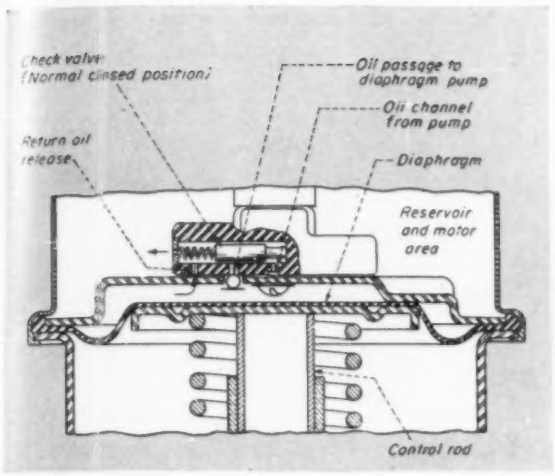
BALL ATTACHED to side of piston and inserted in nylon crank imparts twin action to piston causing it to reciprocate for pumping action and to rotate for valving action. Valves consist of two holes in the pump housing on the piston center line and flat areas on the piston that close both ports when the piston is moved into central position.

Circuit Measures Vibration Decay Constant

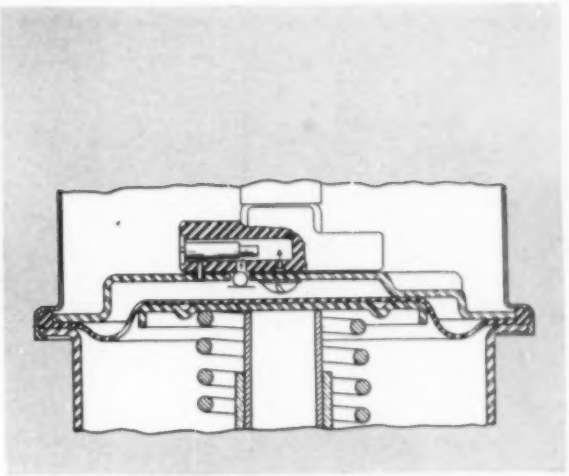
To determine the decay constant of mechanical and electrical vibrating systems, the National Bureau of Standards has developed an electronic instrument that determines this by voltage-amplitude comparison. An electromechanical transducer, such as a quartz plate resonator, is attached to the vibrating system and converts energy from mechanical to electrical. The decaying wave form is then fed into the new NBS instrument.

The heart of this instrument is two identical circuits that amplify, differentiate, and shape the decaying voltage into pulses to trigger a precision counter chronoscope. The circuits have different reference voltages to control the time of initiation of the triggering pulses through each circuit; one reference voltage controls the starting pulse that passes through each circuit; the other passes the stopping pulse on to the chronoscope when the input voltage has decayed to the selected value.

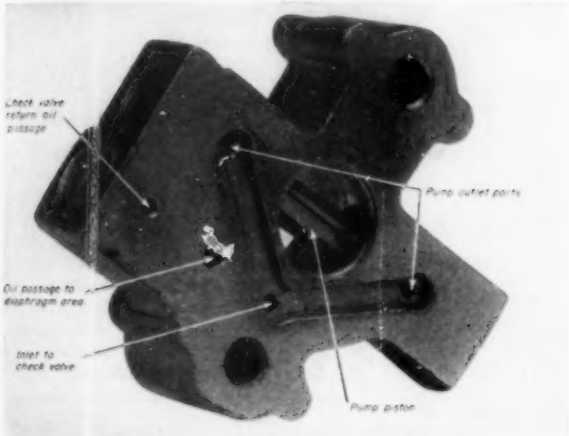
The decaying wave form of the vibration is impressed simultaneously on the cathodes of 6AL5 twin diodes, one in each circuit. In the first circuit the anode is maintained at a selected voltage, like 45 v. As long as the cathode potential, which decreases with



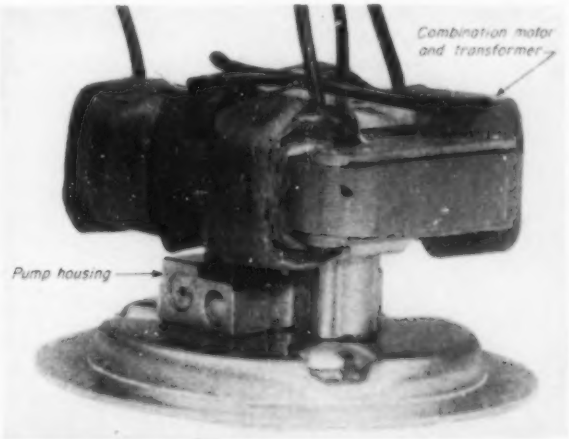
CHECK VALVE is a spring loaded piston that runs parallel to the pump piston. When pump is not operating, valve is closed, and return port is open so that oil flows from the diaphragm area to the reservoir.



WHEN PUMP IS OPERATING, oil pressure forces the check valve against the spring to close the return port and to permit flow to the diaphragm area where oil pressure forces diaphragm downward to move operating arm.



BOTTOM VIEW of pump housing shows oil passage and valve ports. V-shaped channel feeds oil from both ends of the piston pump into check valve chamber. Piston is ground to close tolerance and hole for piston is reamed to a close tolerance.



PUMP HOUSING is connected directly to the motor bearing plate. Housing and combination motor and transformer are immersed in the oil reservoir to eliminate lubrication and leakage problems as well as providing compact packaging. Two clamping screws hold assembly together.

the decaying waveform, exceeds that of the anode there is no conduction through the diode.

But when the cathode and anode potentials become equal a small current flows in the diode circuit so that voltage appears across a differentiating circuit in the grid of a 6BA6 high gain pentode amplifier. This small pulse voltage is amplified, its phase inverted by the pentode, and then impressed on the cathode of the diode. As a result, the cathode voltage is driven lower, and the diode current increases and becomes oscillatory in a time determined by the reactance in the regenerative circuits of the 6BA6.

The circuits following this type of regenerative voltage comparator convert the waveform into a single pulse at an impedance level suitable for triggering the chronoscope.

When the decaying waveform is applied to the second circuit, the output pulse can stop the chronoscope since the reference voltage on the anode of this comparison diode prevents that circuit from functioning until the input voltage has fallen to a value lower than one-half that required to operate the first circuit. The time difference between the two triggerings is a measure of the damping coefficient of the vibrating system.

The error in measuring the time increment is proportional to the length of the increment. Principal error source is inability of diodes to define exact point of voltage equality.

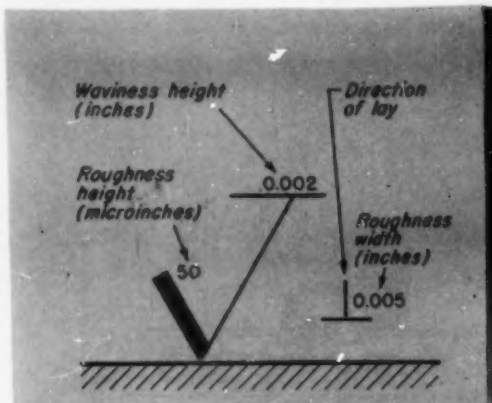


Fig. 2—Complete method of specifying the characteristics of finished surfaces.

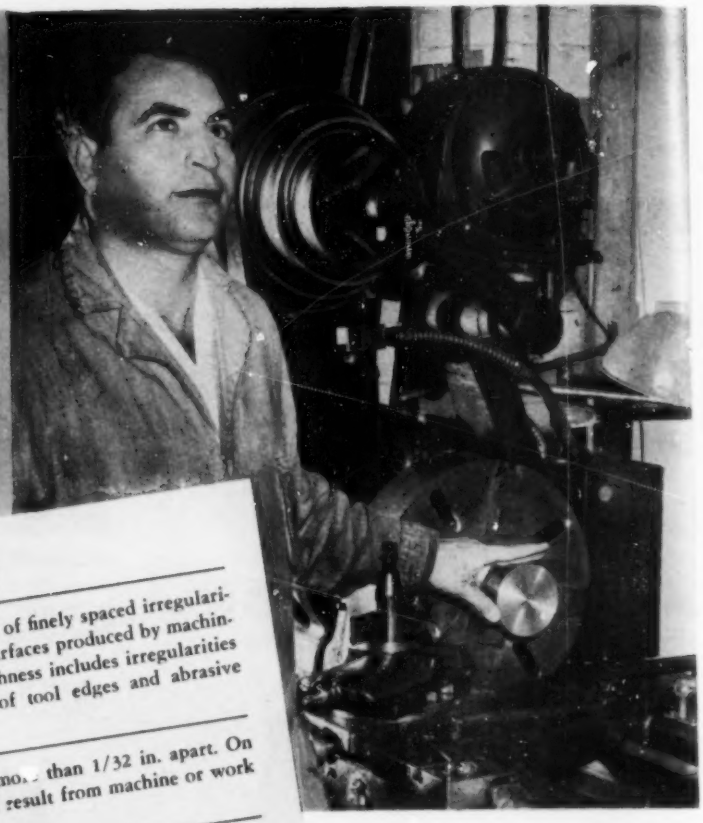


Fig. 1—A turned piece being checked for a finish carefully specified as 63 microinches, RMS. Designer probably visualized a Brush analyzer or Profilometer being used to check this surface. Too often the finish specified on a drawing is only used to establish the machining method and no check is made of the RMS—not even a crude one, like that shown in the photo above.

Table I—Terminology

Roughness	A measure of the height and width of finely spaced irregularities, less than 1/32 in. apart. On surfaces produced by machining and abrading operations, roughness includes irregularities produced by the cutting action of tool edges and abrasive particles.
Waviness	Specified irregularities that are more than 1/32 in. apart. On machined surfaces, waviness can result from machine or work deflections and vibrations.
Lay	Indicates the direction of predominant surface irregularities with these symbols: = parallel to the boundary line of the surface indicated; ⊥ perpendicular to the boundary line; X angular in both directions to the boundary line; *M* multidirection; *C* circular; *R* approximately radial.
Microinch	Equals one millionth of an inch. Thus 63 microinches, often specified as 63 μ in., equals 0.000063 inches.

Some Practical Aspects of

JOSEPH ADILETTA, P.E.
American Machine & Foundry Company

ALTHOUGH THE DESIGNER should normally refrain from dictating to the shop the machines or methods to be used in producing finished surfaces, it is imperative that he have a working knowledge of these processes.

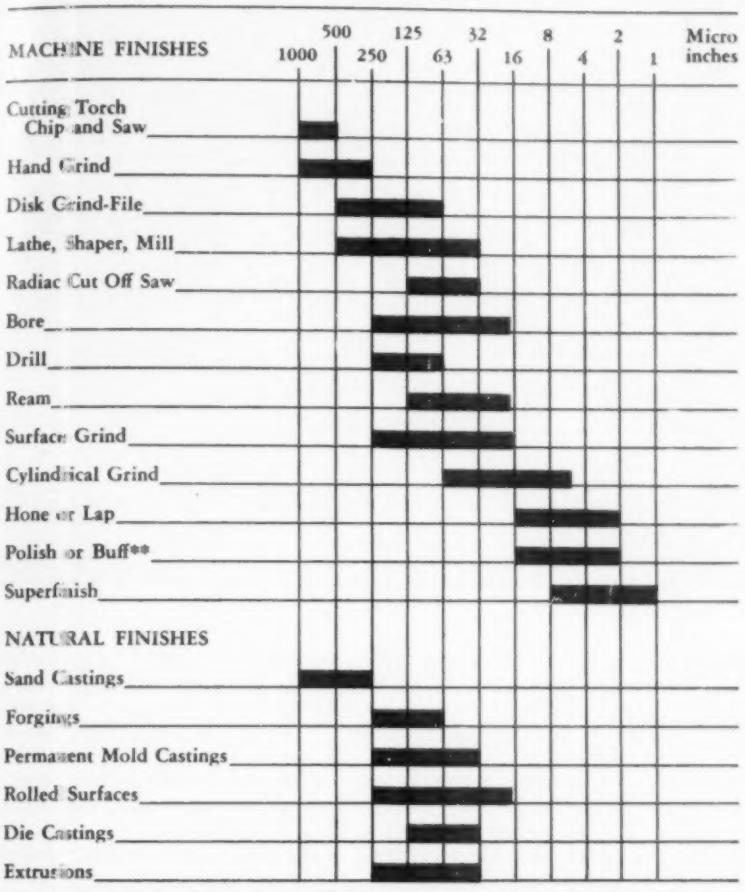
The finishes considered in this article refer to the condition of a surface that result from any particular machining operation. They should not be confused with special processes such as painting, plating or phosphating. Also, they do not include mechanical types of processes that are done for appearance effects only—barrel finishing, for example.

The common method of specifying the control of these surfaces is illustrated in Fig. 2—the symbols and terms being defined in Table I in accordance with the latest SAE standards. As shown in Table II, no appreciable difficulties are encountered, unless irregularities must be less than 30 μ in., RMS.

Generally, normal production equipment, including lathes, milling machines and shapers, as well as many natural finishes, are satisfactory up to this point. For finer finishes, however, fine grinding, lapping, honing or polishing may be required.

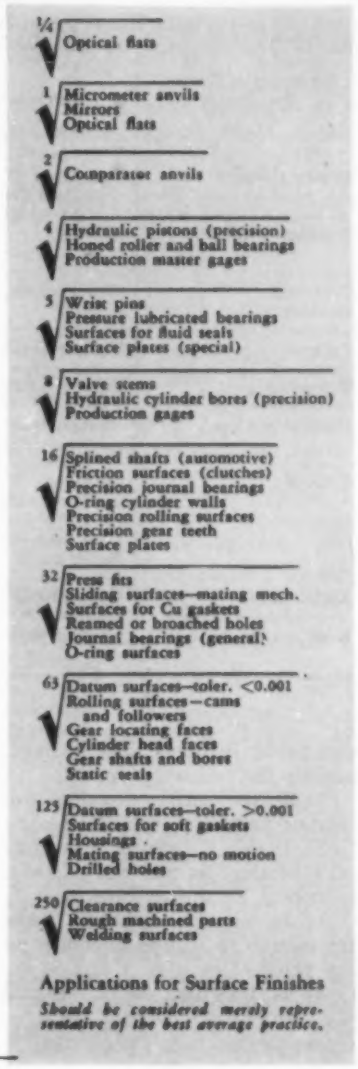
Many of the difficulties associated with surface finish control can be traced to an inadequate understanding of this term RMS, equivalent to root-

Table II—Typical Surface Roughness Values Inherent In Natural and Machine Finishes



**Dependent on previous surface finish and grit and grade of abrasive

Courtesy Industrial Products Div., Elgin National Watch Co.



Applications for Surface Finishes

Should be considered merely representative of the best average practice.

Specifying Surface Finishes

mean-square, which is an average value of surface roughness in this case. That it is an average value becomes obvious when one realizes that different parts of the same surface will have different RMS readings. Amount of variation depends on method to get average.

Considering the surface cross-section in Fig. 3 in which A, B, C, etc. are points equally spaced, and drawing a mean reference line through peaks and valleys parallel to the surface being measured, the following calculations will illustrate the basis of the term.

Points Measured	Average Arithmetic	Average Square
A	5	25
B	2	4
C	2	4
D	3	9
E	1	1
F	3	9
G	5	25
Sum	21	77

Ave. $= 21 \div 7 = 3.0$ microinches

Ave. RMS $= \sqrt{77} \div 7 = 3.38$ microinches RMS.

The RMS average is used primarily because the electronic instruments used to measure surface naturally produce such an average; whereas, the arithmetic average would require different circuits. Such units are available, however, and may be desirable in certain applications.

What Finish to Specify?

The drawing is completed and dimensioned. The designer is about to specify the maximum microinches

Table III—Typical Relationships between Function, Design and Machining Method

Function or Reason For Finish	Sample Part	Acceptable Range of Surface Roughness	Machining Methods	RMS Choice, μ in. & Reason
Sliding surfaces	Disk Cam	5–125 μ in. depending on speed and force	Stamp, turn, profile	32 Profile
Tolerances and friction	Bearing	1–32	Turn, drill, ream	5 Hone (dim. process not satisfactory)
Corrosion Resistance	Water pump piston	1–16	Turn	5 Fine Hone (see above)
Fatigue	Turbine shaft	1–16	Grind	5 Lap
Reference	Pipe or fitting flanges	125–250	Plane, turn	125 Turn
Natural process	Piping—plumbing	32–250 (Extrusions-Forging)	Extrusion	None (Naturally 63)
Quantity	Prototype—Gear in Servomechanisms	Low load, spring-loaded 16–63	Gear cutter and grinder	16 Grind
Size	2 x 4 in. x 10 ft. Roller guide	32–125	Shape, mill, grind	63 Shape
Appearance	Operating Controls	63–125	Cast, brush, tumble	125 (to be painted)
Next process	Casting—cylinder head	63–200	Grind, mill	125

RMS finish. Before he does, he should consider the following factors:

(1) Is the surface to slide over a mating part—such as a cam face?

(2) Is this a shaft for a precision roller bearing, so that the tolerances are critical, or shrink/force fits?

(3) Is corrosion resistance important enough to require minimize pitting points?

(4) Is the part to be critically loaded and reduction of fatigue failure important? Smooth surfaces will reduce stress raisers.

(5) Is this to be a reference plane or surface only?

(6) What machining process is to be used in producing this part dimensionally? The natural finish of the process may be adequate, obviating the need for additional controls.

(7) Is the piece for experimental use or will it go into mass production?

(8) How large is the part itself?

(9) Is the appearance important?

(10) Is any additional processing to follow?

(11) Are surface finishes checked by inspection to see that the specifications are met?

(12) What inspection equipment is available?

As to how the answers to the ques-

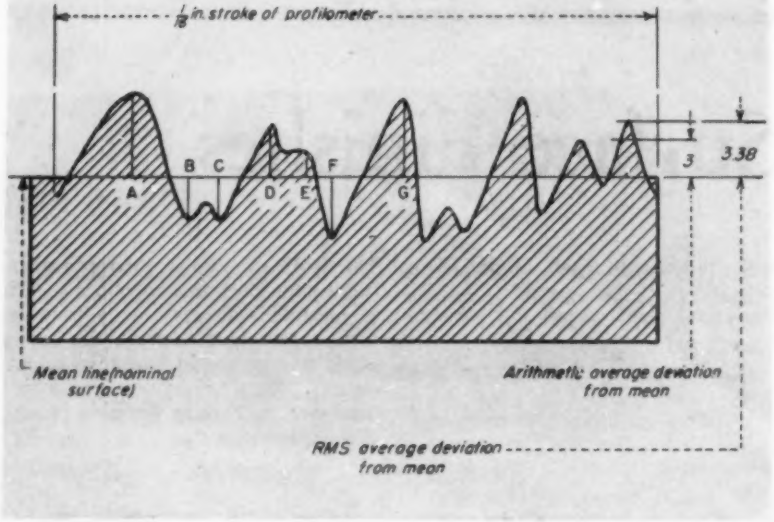


Fig. 3—Comparison of an actual surface contour with an average value to illustrate the meaning and method of calculating the RMS designations.

Shop Name	Roughness Microinches RMS	
	Average	Avg. Peak to Valley
Mirror	4	15
Polished	8	28
Ground	16	56
Smooth	32	118
Fine	63	220
Semi-Fine	125	455
Medium	250	875
Semi-Rough	500	1750
Rough	1000	3500

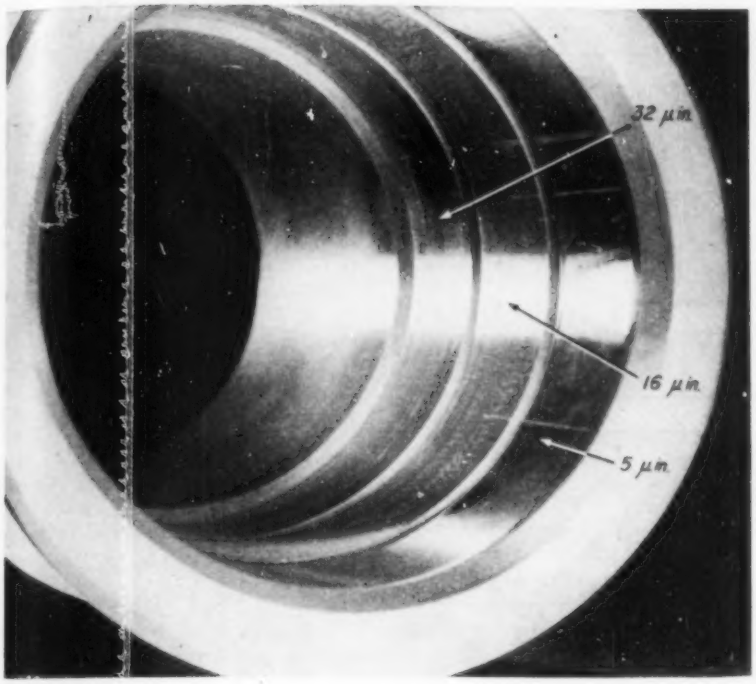


Fig. 4—For illustrative purposes, three different finishes were machined on the ID of this part. The 32μ in. section was ground, the 16 was honed, and the 5 was lapped. From Table II, any one of these operations is theoretically capable of producing the three finishes, but shop experience in this case dictated which of the three processes could best be used for each of the sections.

tions should be interpreted into the final specification, experience is the best criteria. However, data such as that presented herein may often be a useful guide. For example, Table III relates function and design to machining operations. This table is not all inclusive and for different classes of products the final choice will vary. Thus, the functional requirement permits a certain range of surface finishes to be satisfactory and a number of machining operations may be used within that range. The choice may be made according to the equipment available in the shop, or on basis of the machine used to produce a dimension or part. Table II may serve as a guide in the latter case.

Several other factors affecting surface finish control are brought out in Table IV. Here, some typical methods of producing different surfaces and a comparison of costs are given.

The first column is a non-exclusive description often used by shopmen. It is confusing and should generally be discouraged. It is preferable to think in terms of the second column which gives the roughness values in microinches that are generally associated with each class. The fourth column gives typical values of the dimensional tolerances that can be expected.

The next column describes the surface. In applications involving critical sliding or sealing members, the lay and direction of the tool marks may be of considerable importance.

The last column which compares relative costs will overlap and differ among shops and is intended only in the most general way.

Methods of Fine Finishing

Grinding. This is the most common method of producing quality type finishes. Generally, the harder the metal, the softer the grinding wheel should be to prevent tearing grains from the surface. For best results, parts are usually ground at surface speeds between 5,000 and 7,000 feet per minute.

Table IV—Classification of Machined Finishes

Usual Tolerance, in. (Plus or Minus)	Description	Typical Method of Production (Does not include all methods)	Approx. Relative Cost
0.0002	Mirror-like without tool, grinding or file marks, close tolerances	Grind, micro-hone, lap, buff, superfinish	17–20
0.0005	Smooth, no scratches, close tolerances	Grind, hone, lap, burnish, brush	17–20
0.001	Smooth with close tolerances	Grind, roll, file, lap	10
0.002	Accurate bearing surface without tool marks	Grind, roll, precision mill, file	7
0.003	Smooth surface without objectable tool marks, moderate tolerances	Shape, mill, grind, ream, roll, broach, turn	5
0.004	Finished appearance with close dimensional accuracy	Shape, grind, broach, mill, turn	5
0.007	Provides good surface contact	Shape, rough grind, mill, turn	4
0.013	Uniform bearing surface without close tolerances	Shape, rough grind, mill, turn	2
0.025	Rough surface produced by removing stock to nominal diameter	Round nose tool, hack saw, band saw	1

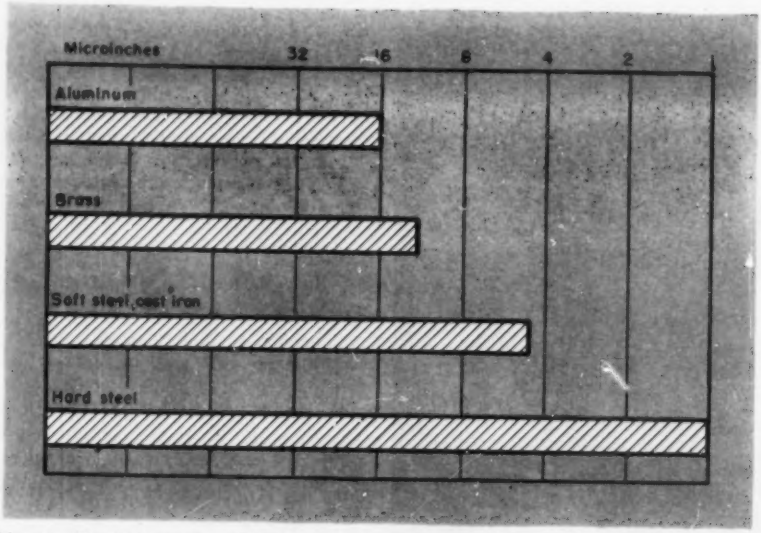


Fig. 5—Typical ranges of RMS values for several groups of common metals.

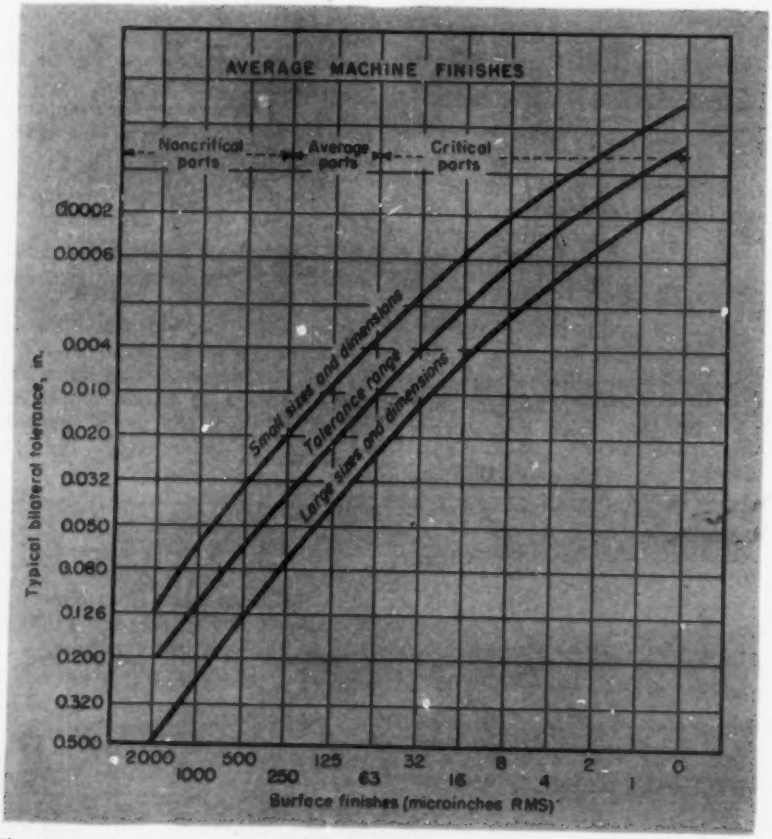


Fig. 6—Graphical representation of surface finishes verses dimensional tolerances including the effects of part sizes. This is intended only as a guide to good practice.

Lapping, Honing. These are used to produce finishes finer than those possible with grinding. Lapping can be done either wet or dry. Wet lapping uses lubricants such as lard and machine oil, gasoline and kerosene or turpentine and alcohol and is characterized by a surplus of abrasive and lubricant. The dry method starts with cleaned surfaces and a limited amount of abrasive; henceforth only kerosene or gasoline is used on the lap and the action is similar to that of an oil stone.

A hone or honing consists of abrasive stones or strips fixed in a metal head or frame. Usually the stones are flexibly mounted under spring pressure to follow contours although today, many honing machines hold the stones rigidly and cut holes to close tolerances.

Superfinishing, which is a close relative of honing, is based on calculated relationships between reciprocating motion, pressure, surface speed, type of metal, hardness of stones and size of the surface.

Polishing and Buffing. Polishing is usually the abrading action that follows grinding and preceded buffing. It is distinguished from buffing in that the abrasive is glued to the face of the wheel. Buffing, which uses a loosely imbedded abrasive, removes very little material and produces a grainless type finish. Neither process can be used very effectively in sharp corners and are difficult as well as expensive when parts have severe changes in contour.

Other Factors

The method of production, unfortunately, is only one of the factors that must be considered when specifying finish requirements. The physical characteristics as well as the initial condition of the material being processed play an important part in the final results. Fig. 5 gives an indication of the limits that exist for commonly used metals. Obviously, the values vary for different alloys within each category. For example, a single grinding cut on a hardened tool steel will produce a smoother finish than the same cut on a stainless alloy like 304, which tends to tear. A fine surface can be made on the 304, but it will cost more and take more time to produce than with the harder tool steel. This principle applies to most alloys.

As illustrated in Fig. 6, the size of the part being finished is another consideration. So is the shape. Other things being equal, a finer finish is possible on small flat stock than on cylindrical pieces. For finishing long lengths such as 14 to 16 ft, a preliminary requirement for a good surface is the initial straightness of the stock. This should be held to 0.010 in. to permit grinding to 30-35 microinches, RMS and plus or minus 0.0015 in. in diameter. If the stock is six feet or less, the finish can be 8-10 microinches, RMS.

As indicated previously, if irregularities are to be less than 30 microinches, commercial production methods are usually unsatisfactory. It might be possible to centerless grind, then lap and hone steel rods that are 15 ft long, but the procedure would be extremely costly and not considered a production run.

Sensitivity of Bearing Materials to Abrasive Dirt in Oil Supply

Embedability rating of bearing materials based on rate of temperature rise in the bearing when lubricated with an oil that contains an abrasive material. Wear and life of journal bearings as affected by the size of abrasive particles in oil and composition of bearing material. Influence of babbitt thickness and the characteristics of the backing materials on the thermal behavior of babbitt-faced bearings lubricated with dirty oil. Use of gridding to improve embedability without decreasing the load-carrying ability.

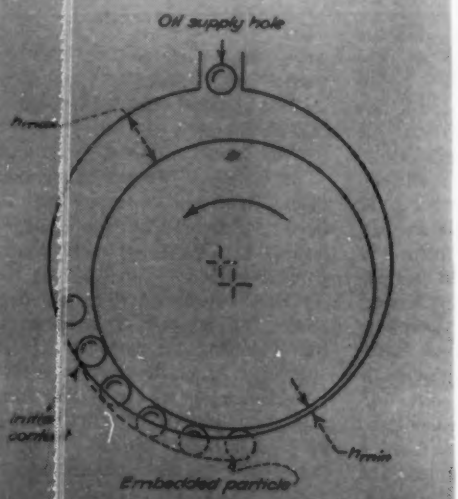


Fig. —Schematic cross-section of a journal bearing. Solid particle of foreign material is dragged by journal rotation into converging clearance and is embedded in bearing metal.

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Research Laboratories Division,
General Motors Corporation

IF ONE CAREFULLY EXAMINES the journal bearings from a machine, such as an internal-combustion engine that has been in service for a considerable time, he will invariably find small particles of foreign material embedded in the bearing surfaces.

These foreign materials come from several sources. They may be dust particles that were inducted into the machine during its normal operation, particles of core sand that were shaken loose from the castings of which the machine is made, or metallic particles that were worn away from rubbing surfaces. Whatever their origin, the particles eventually found their way into the oil sump and then were carried along with the oil as it was pumped through the lubrication system until finally the particles reached the bearings.

What happens when a solid foreign particle enters a journal bearing is indicated in Fig. 1. The particle entering through the oil-supply hole is carried by the oil into the converging clearance space extending from h_{max} to h_{min}. If the particle is smaller than the oil-film thickness h_{min}, it will pass through the bearing without harmful effect. If the particle is larger than the oil-film thickness h_{min}, it will be forced or embedded by the journal into the relatively soft bearing surface. The bearing thus becomes a lap charged with foreign solid particles. When the journal rubs against this charged surface, heat is generated, excessive bearing temperatures result, and the journal is worn away.

Journal wear under such circumstances might be thought to be a self-limiting process. This assumption is true where a bearing contains only few embedded abrasive particles; the particles abrade circumferential tracks around the journal until the tracks become so deep that contact between the journal and the particles in the tracks no longer occurs. In such an

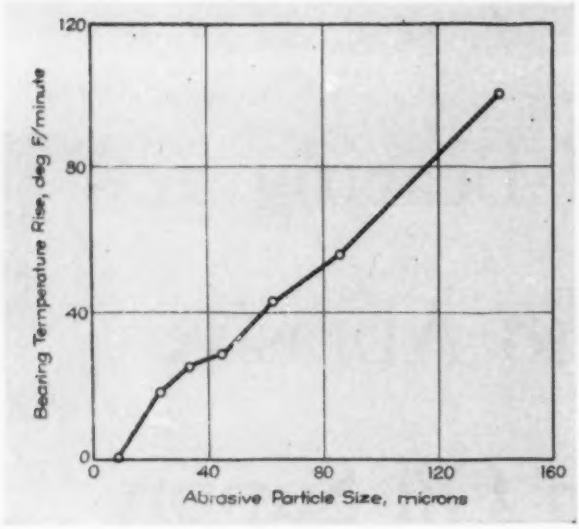


Fig. 2—Thermal behavior of babbitt bearings as a function of abrasive particle size of crystalline alumina in lubricating oil.

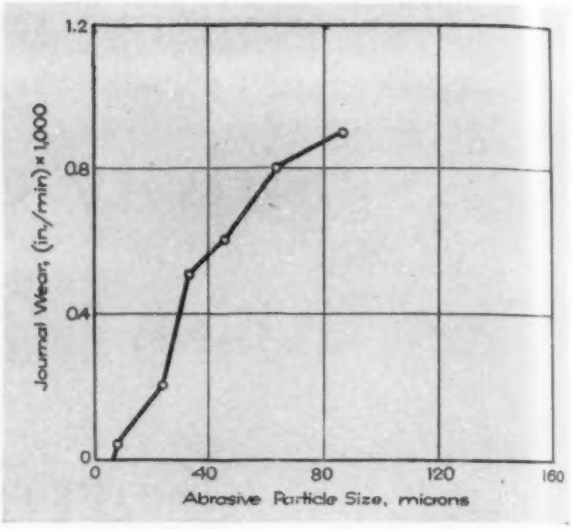


Fig. 3—Journal wear of babbitt bearings as a function of abrasive particle size. Damage increases directly with particle size.

event, there may be no change in the overall clearance between bearing and journal.

But where a large number of abrasive particles are densely distributed over a bearing surface, journal wear may not be self-limiting. Instead, the journal surface may be worn away evenly so that the overall clearance between bearing and journal is increased. This increased clearance causes a reduction in the thickness h_{min} of the load-supporting oil film and permits the journal to bear down on the embedded particles harder than ever. Journal wear under such circumstances is not self-limiting but proceeds until the bearing fails.

The severity of journal wear resulting from abrasive particles depends upon the composition and geometry of the bearing, the hardness and size of the embedded particles, and the composition and hardness of the journal.

While all these factors are interrelated, only two of them can be readily controlled by the machine designer—they are particle size and bearing composition. The former can be controlled by filtration, while the latter can be controlled by making a judicious selection from the several materials available for bearing service. The other factors—bearing geometry and journal composition and hardness—generally are determined by considerations other than dirt tolerance. Particle hardness is essentially uncontrollable, being dependent upon the environment in which the machine operates. Consequently, this discussion is concerned primarily with the factors of particle size and bearing material.

Effect of Particle Size

Since the maximum size of the solid particles that reach the bearings in a machine can be controlled by filtration, the question arises: What is the allowable maximum size? On the basis of hydrodynamic theory, it is to be expected that abrasive particles smaller than the minimum thickness h_{min} of the load-supporting oil film have no effect on bearing performance and durability insofar as friction coefficient and journal wear are concerned. This assumption has been substantiated experimentally.

For particles larger than the minimum oil-film thickness h_{min}, however, the harmful effect of solid particles in the oil increases almost directly as the nominal size of the solid particles.

Using the rate of bearing temperature rise as a measure of the rate of bearing failure, the severity of abrasive action in bearings is indicated by the test results plotted in Fig. 2. The tests were conducted with $\frac{1}{4}$ in. dia by $2\frac{5}{16}$ in. long bearings lined with a lead-base babbitt of approximately 0.002 in. thickness. The minimum oil-film thickness was about 0.0002 to 0.0003 in. In each test, the bearings were lubricated with oil containing crystalline alumina particles of known size in a concentration of 1 gram per gallon.

For particles smaller than about 6 to 8 microns, no temperature rise resulted from the presence of foreign solid particles in the oil. This size of particle (25.4 microns equals 0.001 in.) corresponds to the minimum oil-film thickness.

Corresponding data for rate of journal wear as a function of abrasive particle size are shown in Fig. 3. As before, the severity of damage increases almost directly with increase in particle size.

These experimental results demonstrate that to protect bearings from harmful abrasive particles, all particles larger than the minimum oil-film thickness h_{min}, which in this instance was about 0.0002 to 0.0003 in. must be filtered out of the oil. Such filtration is readily accomplished if one is willing to pay the price.

With filters of conventional design, the maximum size of solid particles that will be passed by the filter can be reduced to any desired value simply by increasing the density of the filter medium. The pressure drop per unit area of filter surface, however, increases with increase in density of the filter medium. The power required to pump oil through a unit area of the filter surface, therefore, also tends to increase as the "fineness" of filtration is increased. The loading rate, which is the rate at which the filter medium loads up with particles, likewise increases with the "fineness" of filtration so that more frequent replacement of the filter is necessary.

To keep the pressure drop and loading rate at reasonably low values, and still filter out of the oil all particles larger than the minimum oil-film thickness h_{min} of a heavily loaded bearing, requires an area of filter

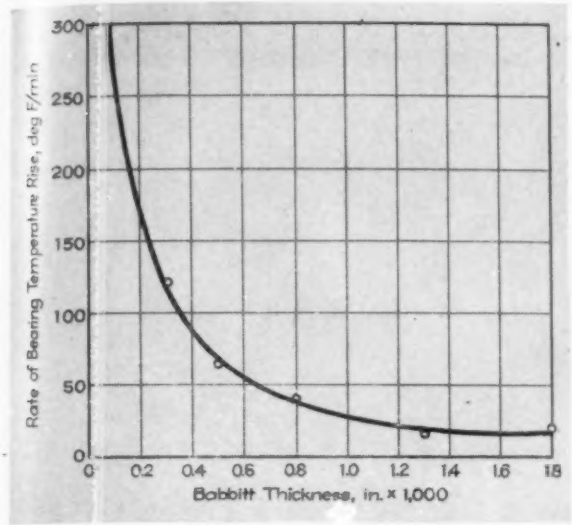


Fig. 4—Thermal behavior of babbitt-faced copper bearings as a function of babbitt facing thickness when tested with dirty oil.

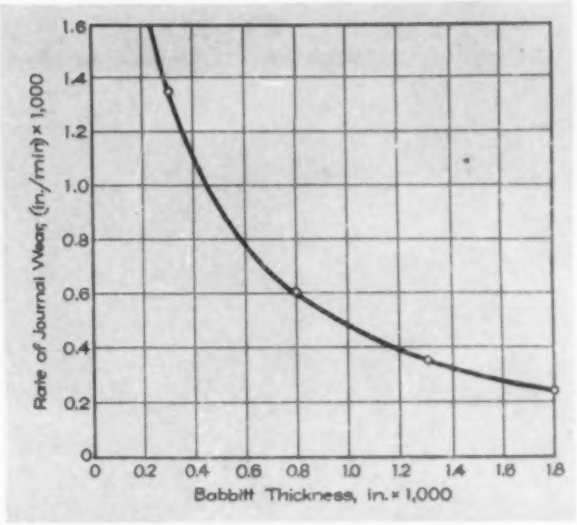


Fig. 5—Journal wear of babbitt-faced copper bearings as a function of babbitt facing thickness as tested with dirty oil.

surface much larger than the average engineer is willing to accept. With full-flow cartridge-type filters of conventional design and size, the limit of "fineness" of filtration for a new filter is about 0.0010 in. This value is about five times that of the minimum oil-film thickness of the bearings used in the journal wear tests. What this adds up to is that filtration is a thorny problem for engineers to solve.

So long as the practical limitations of existing filter designs compel the acceptance of something less than the ideal degree of filtration, bearings must have the ability to tolerate some abrasive action. Certain bearing materials are relatively tolerant of dirty oils; other materials are quite sensitive to them. Which type of bearing material must be used in a particular location depends largely upon the severity of the operating conditions, both as regards load and speed.

Bearing Materials

From a technical viewpoint, the most important properties of a bearing material are: Score resistance; compressive strength and fatigue strength; embedability and conformability; and corrosion resistance.

While no definitions of these properties are universally accepted, their meaning is clear to most engineers. Score resistance is a measure of the ability of a bearing material to resist seizure or welding to the journal. Compressive strength is a measure of resistance to plastic deformation or yielding under static load, while fatigue strength is a measure of resistance to fracture or yielding under repeated loads. Embedability is a measure of the ability of a bearing material to yield locally in such a manner that solid foreign particles may be embedded into it, while conformability is a measure of the ability of a bearing material to yield locally in such a manner that the bearing surface may adjust itself to imperfections in journal geometry, edge loading, and the like. Corrosion resistance is a measure of resistance to chemical attack.

It is readily seen that not all of these properties are mutually compatible. Thus, the ability to resist yielding as required for compressive strength and fatigue strength is incompatible with the ability to yield locally as required for embedability and conformability. Similarly, under certain conditions, chemical inertness is incompatible with score resistance. The problem of the bearing designer in selecting a bearing material is to find a suitable compromise between these conflicting requirements.

For many years in the development of bearing materials for heavy duty applications, such as internal-combustion engines, the property of fatigue strength has received considerable attention. As engine speeds and compression ratios were increased, the loads increased on main and connecting-rod bearings. The fatigue strength of the thick babbitt bearings that were used in early engines was eventually exceeded and, as a result, bearing fatigue thus became a prime problem in later engine development.

In the solution of this problem, two stratagems proved to be effective. The first was to abandon the use of babbitt as a bearing material and to employ in its stead various harder materials such as copper-lead. The second was to increase the effective strength of the babbitt by drastically reducing its thickness. The effect of these changes upon the ability of the bearings to tolerate dirty oils was soon apparent, and interest in embedability as a property of bearing materials largely stems from these developments.

Effect of Babbitt Thickness

The rate of bearing temperature rise as a function of babbitt thickness for a series of $\frac{11}{16}$ in. dia by $2\frac{5}{16}$ in. long babbitt-faced copper bearings, which were tested with an oil containing a fixed concentration of 28-micron crystalline alumina, is shown in Fig. 4. The corresponding data for rate of journal wear are shown in Fig. 5. The severity of abrasive action is reduced as the thickness of the babbitt is increased, until finally a babbitt thickness is reached beyond which no further reduction in temperature rise is obtained.

Under the conditions pertaining to Fig. 4, no further benefit was obtained from increasing babbitt thick-

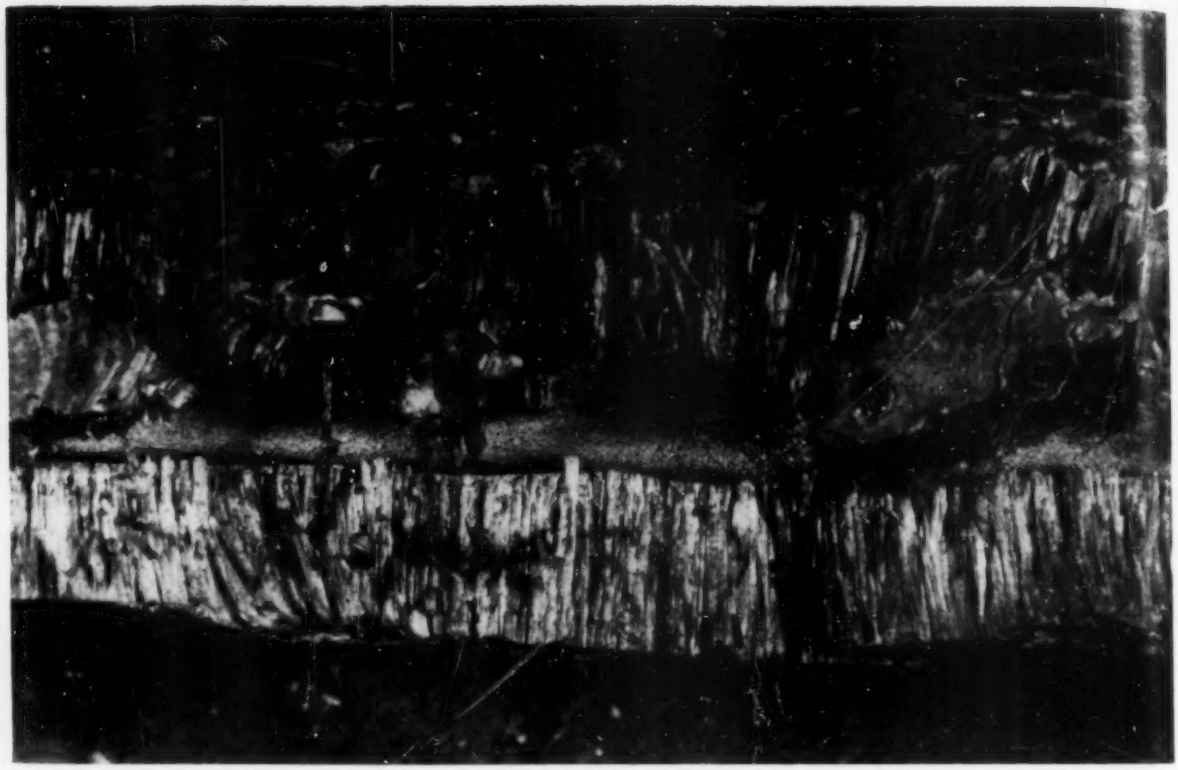


Fig. 6—Steel-backed copper-lead strip bent so as to expose the needle-like structure of the copper constituent in the solidified alloy.

ness above about 0.0013 in. This thickness is approximately equal to the size of the abrasive particles used in the tests. This observation indicates that to minimize the effects of abrasives, the babbitt thickness should be at least as large as the maximum size of the solid particles that may pass through the filter. Babbitt thicknesses greater than this value yield no additional benefit insofar as abrasives are concerned and, indeed, cause a rapid reduction in fatigue strength. To obtain the optimum fatigue strength, the babbitt should be as thin as possible, consistent with embedability requirements.

When the babbitt is substantially thinner than the maximum size of the abrasive particles in the oil, the characteristics of the underlying material exert a large influence on the embedability performance of the bearing. This influence is indicated in Table I, which gives a comparison of test results for babbitted copper bearings and babbitted aluminum bearings, both having been run under substantially the same conditions of abrasive size and concentration. Halving the babbitt thickness of the babbitted copper bearing in the given range caused an increase of 110 percent in the rate of bearing temperature rise, while halving the babbitt thickness of the babbitted aluminum bearing caused an increase of only 25 percent.

Table I—Thermal Behavior of Babbitted Copper Bearings and Babbitted Aluminum Bearings

Babbitt Thickness, in.	Rate of Bearing Temperature Rise, deg F per min	
	Copper	Aluminum
0	3300	280
0.0004	85	51
0.0008	40	41

The difference between the thermal behavior of the two types of bearings became increasingly pronounced as the babbitt thickness was further reduced, approaching the embedability performance of the underlying copper or aluminum as a limit.

Effect of Copper-Lead Composition

The copper-lead materials are much better than babbitt for fatigue strength but not so good for score resistance or embedability. Copper and lead are virtually insoluble in each other in the solid state.

The material is usually prepared by casting a molten mixture of copper and lead on hot steel strip. The copper solidifies first in the form of needle-like crystals, which stand perpendicular to the steel strip and are bonded to it. The melted lead flows into the spaces between these copper needles and then solidifies. The resulting structure is shown in Fig. 6, which is a reproduction of a photograph of a strip that has been bent to expose the needle-like structure of the copper constituent.

The maximum quantity of lead that can be incorporated into a cast copper-lead bearing is about 45 percent. Where a larger quantity of lead is desired, the material can be prepared by compacting copper and lead powders and then sintering them together at elevated temperature.

Careful tests on copper-lead bearings containing varying amounts of lead show that increasing lead content reduces fatigue strength and increases embedability. The ability of a copper-lead bearing to tolerate dirty oils varies directly as the percent of lead for compositions in the range normally used. More important, however, despite differences in composition, the effect of dirty oils with copper-lead bearings is always about ten times as severe as with babbitt, other things being equal.

Effect of Gridding

When bearing loads exceed the fatigue strength of copper-lead, it becomes necessary to use hard homogeneous materials such as pure silver. Pure silver possesses exceptionally good fatigue durability but exceptionally poor embedability. The embedability of such materials may be substantially improved, without adversely affecting their fatigue strength, by means of a technique known as gridding.

The construction of a typical gridded bearing is shown in Fig. 7. The silver layer, which is bonded to a steel back, has a large number of small indentations formed by a knurling tool. These indentations are filled with babbitt. The bearing is then bored to obtain a smooth surface consisting of a large number of babbitt areas surrounded by an interconnected grid or network of silver. The babbitt areas confer good embedability to the bearing, while the supporting silver grid provides the necessary fatigue strength and load-carrying ability.

The embedability of a gridded bearing is influenced largely by the size and spacing of the babbitt areas. Coarse grids have better embedability than fine grids but tend to lose their babbitt filling more rapidly in service. The range of grid spacing is varied in practice from that produced by a 10-pitch knurl to that produced by a 62½-pitch knurl, while the depth of the pockets and the ratio of babbitt area to silver area is controlled by the depth of the final boring out. In any event, the arrangement of the grids should be such that all paths in the direction of journal rotation wipe across babbitt pockets and so prevent abrasive particles from making long scratches over the bearing surface.

Embedability Rating of Bearing Materials

Results of a large number of embedability tests on various bearing materials are summarized in Table II, all tests being carried out under substantially the same test conditions.

The relative embedability performance as given in Table II is based on the rate of temperature rise suffered by the bearing when it is run on abrasive-containing oil. Lead-base babbitt, approximately 0.002 in. thick, is arbitrarily assigned a rating of 100; all other ratings are relative to this value. Thus, a rating of 5 for copper-lead (70 Cu, 30Pb) indicates that this material has 5 percent as much tolerance for dirty oil as lead-base babbitt.

From the data given in Table II it is apparent that the relative embedability of a bearing material is inversely proportional to its hardness. The soft materials such as babbitt rate high. These materials deform plastically to absorb abrasive particles and thus minimize the amount of journal cutting. At the same time, the score resistance of the material also plays an important part of conditioning embedability performance. In comparing two materials of the same hardness but of different score resistance, the material with the better score resistance will also have the better embedability.

Perhaps the most important point evident from Table II is the great effect of thin babbitt facings on embedability performance. This effect can be seen by comparing the performance of identical materials both with and without babbitt facings; for example, copper, copper-lead-tin, and aluminum. Here again it is observed that while the softness of the babbitt facing, acting plastically to reduce the contact pressure between the embedded particle and the journal, is undoubtedly the important factor, the score resistance conferred by the babbitt facing is also important. It would be difficult otherwise to account for the large improvement effected by a babbitt facing of only 0.0003 in. on copper with abrasive particles measuring over 0.001 in. and a minimum oil-film thickness of approximately 0.0002 to 0.0003 inch.

Table II—Summary of Embedability Test Results

Bearing Composition	Relative Embedability
Lead-base babbitt (0.002 in. thick)	100
Lead-base babbitt (0.032 in. thick)	124
Tin-base babbitt (0.005 in. thick)	145
Silver (oxygen-free)	0.6
Copper (oxygen-free)	0.4
Gridded copper (48-pitch, filled)	32
Gridded copper (48-pitch, unfilled)	0.4
Copper + 0.0018 in. babbitt	100
Copper + 0.0013 in. babbitt	100
Copper + 0.0008 in. babbitt	50
Copper + 0.0005 in. babbitt	32
Copper + 0.0003 in. babbitt	17
Copper-lead (60 Cu, 40 Pb)	7.5
Copper-lead (65 Cu, 35 Pb)	5.5
Copper-lead (70 Cu, 30 Pb)	5.0
Copper-lead-tin (75 Cu, 24.5 Pb, 0.25 Sn)	4.0
Copper-lead-tin + 0.001 in. babbitt	69
Aluminum alloy (95 Al, 4 Si, 1 Cd)	10
Aluminum alloy + 0.0008 in. babbitt	68
Aluminum alloy + 0.0004 in. babbitt	55

For babbitt facings on materials not listed in Table II, the ratings will be substantially independent of the underlying material so long as the babbitt is thicker than the maximum particle size. For thinner babbitt facings, the influence of the underlying material on the relative embedability rating must be taken into account.

With regard to babbitt, the experiments have consistently failed to show any significant difference between the embedability characteristics of the various alloys. Lead-base babbitts consistently give a rating of about 100. This rating does not appear to be measurably affected by the presence of minor constituents such as copper, antimony, nickel, and the like. Tin-base babbitts rate somewhat higher, but differences in embedability rating at the upper end of the scale do not appear to be significant in service. Differences in embedability rating at the lower end of the scale, on the other hand, are very significant.

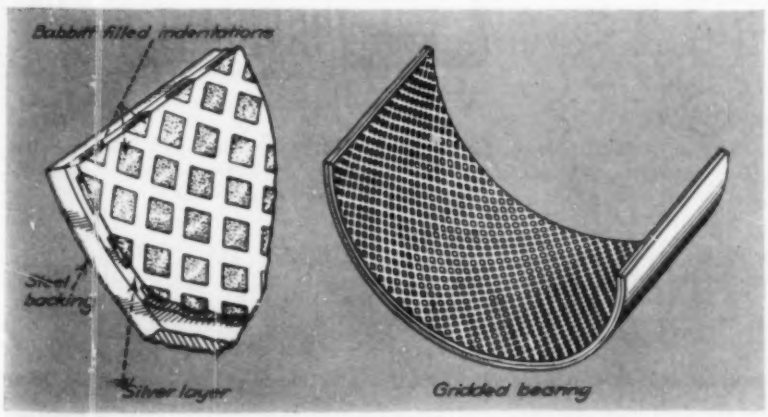


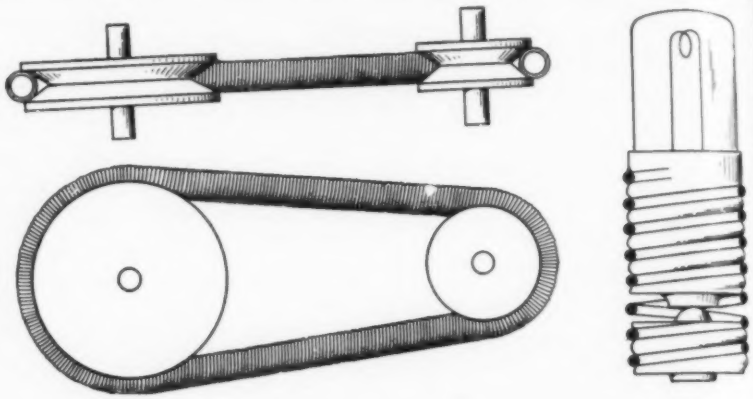
Fig. 7—Construction of a gridded silver bearing. Silver layer is bonded to a steel backing. Indentations in face of silver layer are filled with babbitt.

Unusual Uses for Helical

A selection of practical applications that are characterized by the functions served in each case by the helical wire spring. The spring rate property is put to use in

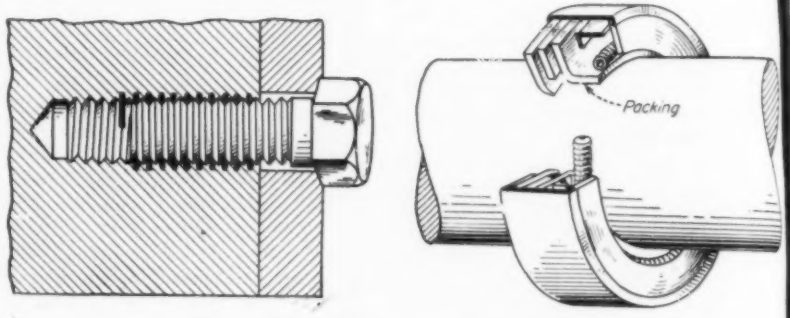
SPRING BELTING (left). For low power transmission at high speeds. Allows a certain amount of variation in the center distance and absorbs inertia forces. Spring ends can be joined smoothly by using a smaller internal spring as shown on the following page.

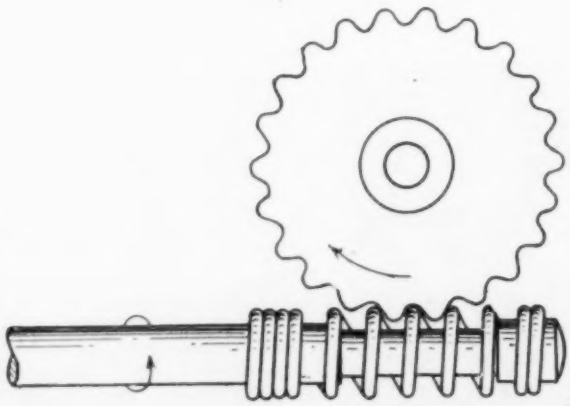
ELECTRICAL FITTING (right). An inexpensive lamp or fuse socket which insures proper contact even when subject to moderate vibration. Small threaded parts can be joined in this way.



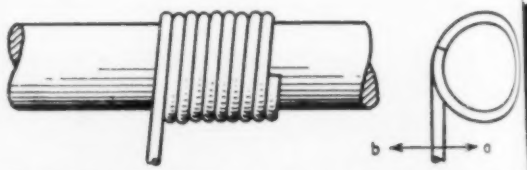
SCREW THREAD INSERTS (left). Used for tapped holes in light alloys and plastics. When joining dissimilar metals, they can be made of stainless steel.

ROTATING TYPE OIL SEAL (right) uses helical wire spring to exert a radial force on the packing. Friction is kept to a minimum and efficiency is high even at high shaft speeds.

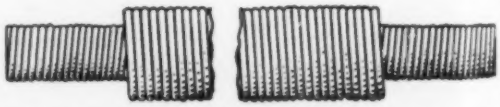




WORM GEARING. Used on low power transmissions. Allows a certain amount of misalignment between worm and wheel. Wheels can often be made from laminated plastics.



FRICTION RATCHET. Spring rotates shaft when pulled in *a* direction, but turns freely on the shaft when pulled in *b* direction.



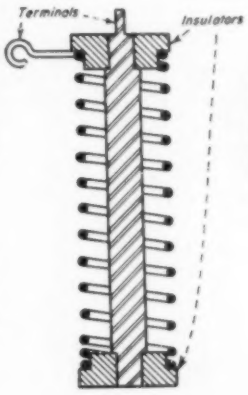
FLEXIBLE SHAFT. Inner spring serves as shaft, outer one is a casing. For single direction of rotation unless shaft consists of two or more springs wound in opposite directions.

Wire Springs

HAIM MURRO
Consulting Engineer

most cases, but not in the axial loading sense that represents the more common applications for which these elements are employed in industrial products.

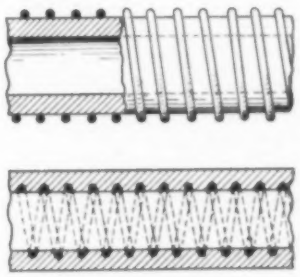
SENSITIVE STICK (left). Round conductor bar is mounted within a spring fastened to insulators to serve as an electrical switch. Deflecting the spring laterally completes the circuit. Can operate relays or alarms and can be made with intermediate insulators where considerable length is required.

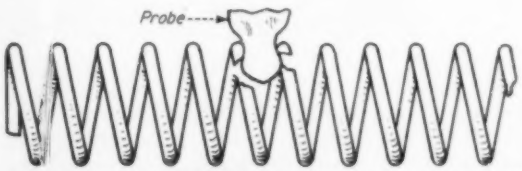


THREAD MEASURING GAGE (right). Dimensions *a* is the effective thread diameter. Pressing the loops together releases the gage from the member. Can be used on fluted parts such as conventional thread taps.

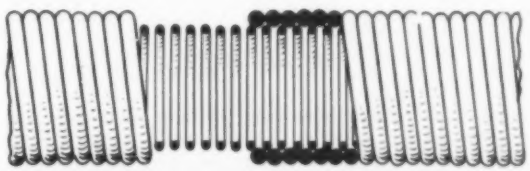
FLEXIBLE CHUTE (left). For feeding small articles from hoppers to automatic machines. Spring can be wound in different shapes as required by the articles being handled.

TUBING REINFORCEMENT (right). Gives plastic or rubber tubing added rigidity as well as protection against mechanical damage. Can be cast inside rubber as shown in lower sketch.



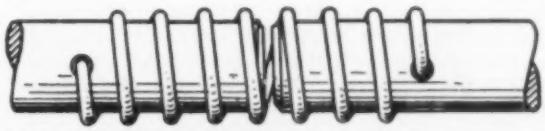


ELECTRICAL CONNECTION for small, light products like hearing aids uses a special probe that is easily inserted between coils of spring which is a conducting material.



SMALL SPRING connects ends of larger spring with a thread-like action. Useful where external projections cannot be tolerated like the spring-belting on opposite page.

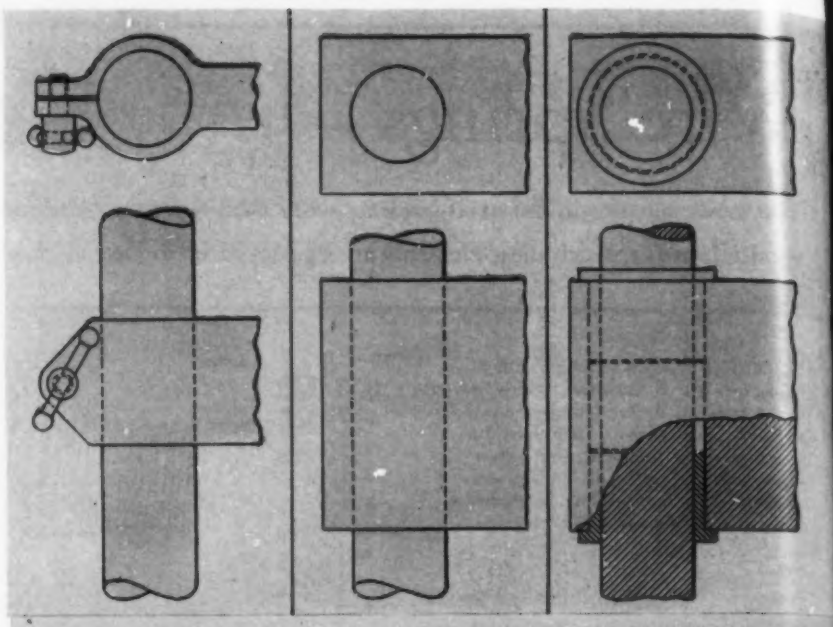
SHIELD FOR ELECTRICAL WIRE AND CABLE. Provides wear resistant covering for wires and protection against physical damage.



SMALL DIAMETER SHAFT COUPLINGS. Allows for some misalignment and can be used with shafts of unequal diameters. For single direction of rotation only.

Round Bar Slides for Machines

W. A. S. DOUGLAS
Northrop Aircraft, Inc.



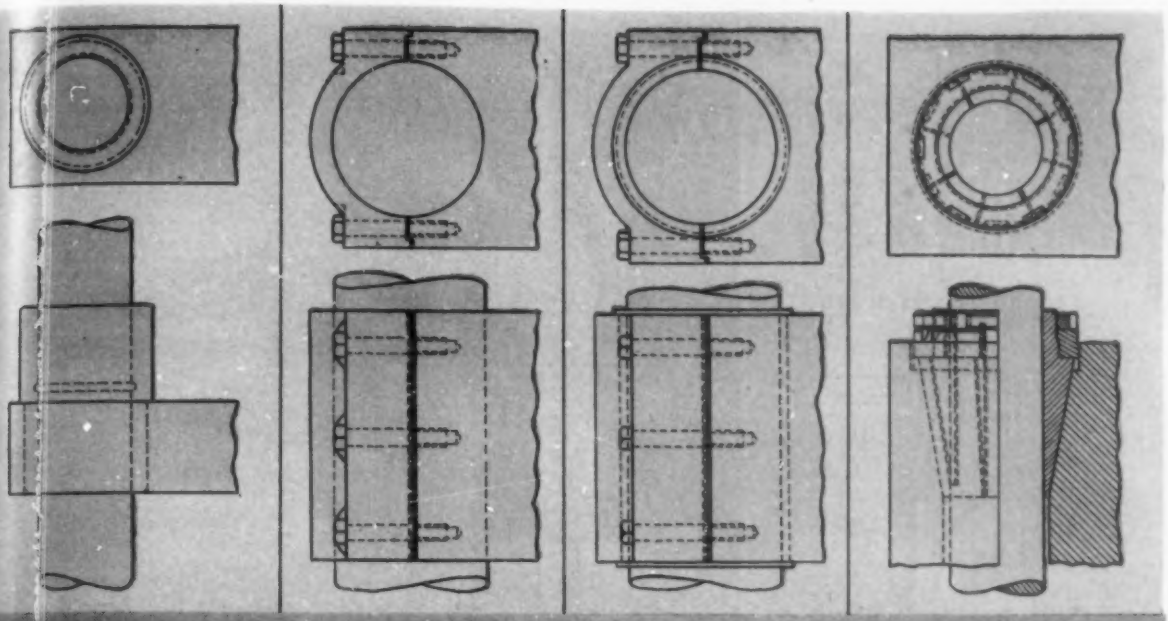
SLIDE TYPE		
Split Housing	Reamed or Bored Housing	Bronze Bushings
GUIDE TYPE		
Cold Rolled, Turned and Polished, or Ground Shaft	Cold Rolled, Turned and Polished, or Ground Shaft	Turned and Polished, Ground, Hardened and Ground, or Chrome Plated Shaft
PROVISION FOR WEAR		
Split	None	Replace bushings
CHARACTERISTICS		
Positive lock-up eliminates play. Used for positioning or adjustment.	Cheapest. Used where relative motion is infrequent, or play between mating parts can be tolerated.	Generally best compromise between low cost and good performance where relative motion is great, where play must be kept to a minimum, or surface speeds are high.

THE USE OF ROUND BAR GUIDES on machine tool slides should be restricted primarily to such applications where: they are loaded as columns rather than beams; where torque is about the center of the guide, or about the center of several guides arranged in a circle; and where thrust is through the longitudinal axis of the guide or ram, or through the center of a circle of guides. If round bar guides are to be loaded as beams, they should be as short as possible, and as large in diameter as possible. Bushings riding on round bar guides should be as long as possible, and their length should preferably approach the distance between guide bars on multiple guide bar installations.

Consideration should also be given to the effects of wear and methods provided to minimize or compensate for it. The surrounding structure should be sufficiently rigid to restrain the rods and prevent deflections of the rod from distorting other parts of the machine, and vice versa. Thought must also be given to the probable life expectancy and frequency of use of any given slide, as design requirements of a slide used once a day would be very different from a slide used several times a minute.

In the case of single round guides, they can be used as machine tool slides where the bars are used as columns, and where there is little motion between the guide and slide. A common application of this principle is in the columns of drill presses and radial drills, where the single tubular column provides for vertical adjustment of the work head or table, and also allows for rotation about the vertical axis of the column, Fig. 1. Wear of both column and bushing is negligible, and, as no relative motion is required during operation of the machine, simple split bushings can be used to lock the bushing to the column, eliminating all play between the two elements.

This same principle has been used successfully on tool



	Hardened and Ground Steel Bushings	Split and Bolted	Split Babbitted or Bronze Bushings	Tapered Bronze Bushings
	Hardened and Ground Shaft	Turned and Polished, or Ground Shaft	Turned and Polished, or Ground Shaft	Turned and Polished, Ground, Hardened and Ground, or Chrome Plated Shaft
	Replace bushings or shaft, or both	Remove shims, hand scrape. Often limited by alignment considerations.	Shim, hand scrape, or replace bushings	Tighten bushings, replace bushings when worn out
	Good wearing qualities; Close fit. For high speeds and high loads. Generally restricted to shafts under 3 in. dia. Costs high unless quantities are large, or stock bushings and shafts are used.	Used on heavy machinery where relative motion is small and speeds slow. Sometimes used as a lock-up.	Used on heavy machinery where close fits must be maintained, where there is considerable relative motion or high linear speeds.	For precision equipment where close fits must be maintained at all times. Where speeds are high, or strokes long. Expensive. Generally not used on shafts under 1½ in. diameter.

and cutter grinders. In one grinder the grinding head is attached to a stationary vertical column by a split bushing, where it can be raised and lowered or rotated about the column to any desired position. In another machine the grinding head is rigidly attached to the top of the vertical column, while the column itself can be moved up and down and rotate in bushings in the machine base.

When round bar guides move from the vertical to the horizontal position, they generally change their function from columns to beams, and in so doing become notably less desirable than their dovetail counter parts. By their very nature round bars can be supported only at their ends, making them subject to deflections throughout their length, while the dovetail slide can be supported throughout its length by a base or beam sufficient to keep it rigid at all times. If round bar guides are to be used to their best advantage, the reaction to the work being done, or the force applied should be through the longitudinal axis of the guide or as a torque about this axis.

A common example of this is the tailstock spindle of an engine lathe when used to drill a hole. Here the thrust line is down the center of the spindle, torque is around the center being resisted by a key and key way. The spindle is loaded as a short column and a torsion bar and any deflections from these will not cause the location of the tool relative to the work to change. When the tailstock spindle is used as a support for the end of the work being machined, it loses its function as a column and becomes a beam, a function for which it is not best suited, as deflections will cause a change of position between the tool and work, resulting in chatter and inaccurate work. When used in this function, the spindle is always retracted into its supporting housing as far as possible to reduce the overhang of the beam, and so reduce or eliminate deflections.

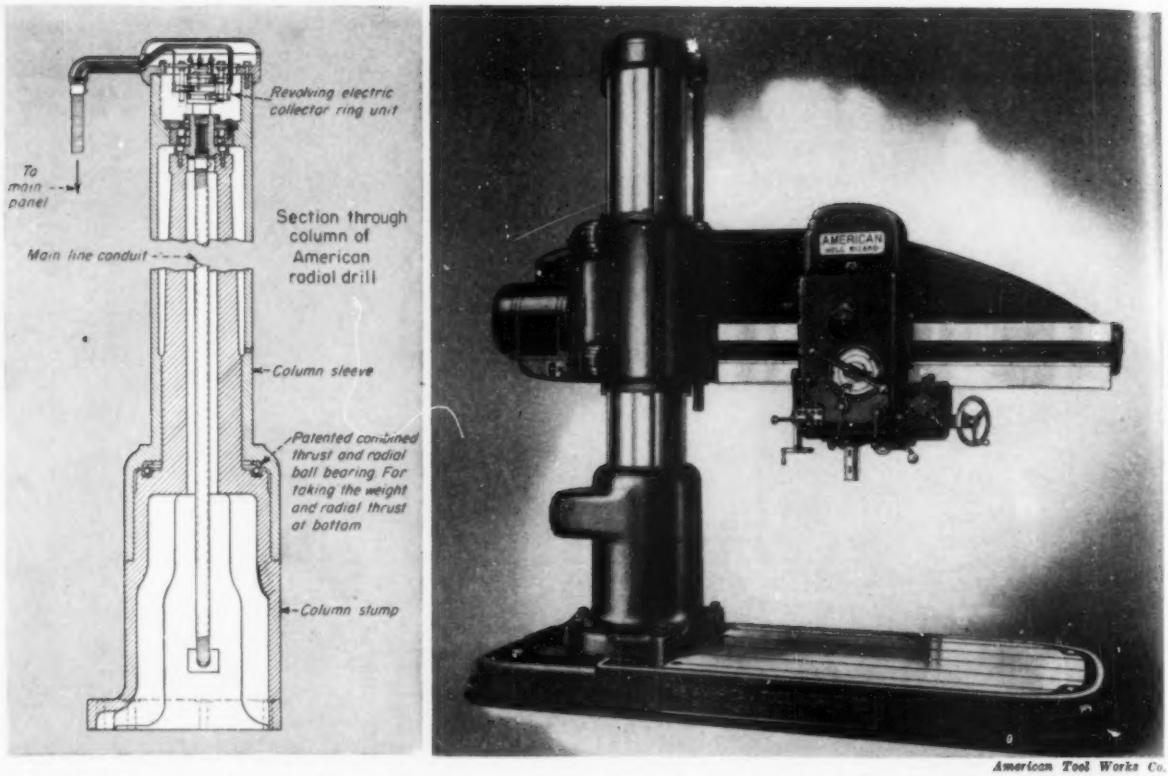
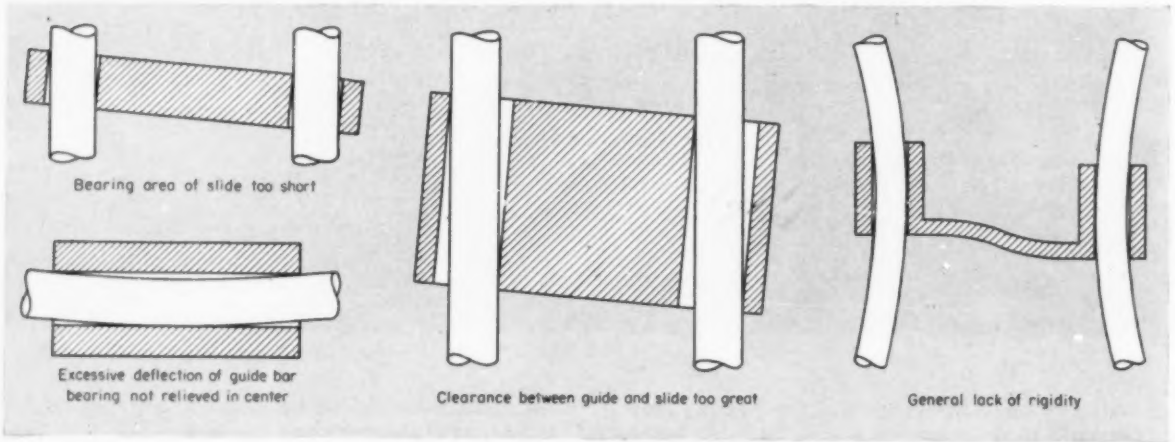

Revolving electric collector ring unit
To main panel
Section through column of American radial drill
Main line conduit
Column sleeve
Patented combined thrust and radial ball bearing For taking the weight and radial thrust at bottom
Column stump
AMERICAN
American Tool Works Co.

Fig 1—The vertical round column of this radial drill is used for vertical adjustment only, the column itself being mounted on ball bearings to provide radial movement about the column center line. A cross-sectional view of the column is shown at left.

Some Causes of Sticking or Locking of Slides on Multiple Round Bar Guides


Bearing area of slide too short
Excessive deflection of guide bar bearing not relieved in center
Clearance between guide and slide too great
General lack of rigidity

Another example is the ram on the Cleveland and Footburt single spindle automatic screw machine, Fig. 3. Here a round bar of large diameter and short length is mounted in a housing or bushing so that it can move in and out and also turn about its axis. The purpose of this is to present several tools to work in quick succession and advance each of them into the work to perform their task. The tools are arranged in a circle about the longitudinal axis of the ram so that their line of action is parallel to that axis. Each tool position has a key way which engages a retractable key to line the tool up with the work and permit indexing from tool to tool. Loads are predominantly thrust loads parallel to the axis of the ram and within its diameter. Torque is resisted by the key, together with the fit of the ram in its housing. Any cut that would load the ram as a beam, such as boring or knee tool work, is amply supported, as the diameter of the ram is approximately the same as its maximum projection from the housing, which will make it a very sturdy beam.

Following the single round bar guides come multiple round guides used as columns, Fig. 4. Where they are used for adjustment only, they have the advantage over machined dovetails in lightness, with a consequent saving in material and fabricating cost, which is particularly noticeable in large machines that otherwise

might require a massive cast iron column. On smaller machines the added precision machine work required to obtain interchangeability of columns, bushings, work heads and column supports could easily offset the material savings. The advantage of two columns over the single columns mentioned is obviously that rotation about the column is prevented. The disadvantage on machines where adjustment is the only function of the column is the close tolerances required on parallelism, and center to center distances of the columns and bushings.

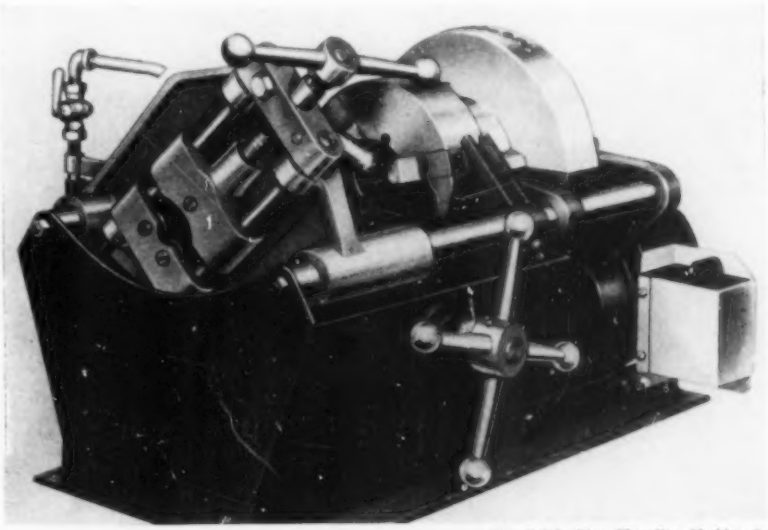
Where the columns are used as guides on a machine where there is relative motion between the guide bars and bushings on the work head, other factors must be considered. Where there is relative motion, there is potential wear, and some means must be provided to compensate for it. The cheapest way to provide for wear from the standpoint of manufacturing economy is with comparatively hard guide rods and soft bushings, such as steel rods and bronze bushings, so that the majority of wear will be on the bushings, which can be replaced.

The disadvantage of this is that from the minute the new machine is put into operation until the time the bushings are replaced, the machine is in the process of deteriorating, losing its efficiency with every stroke until it is rebuilt and then the cycle is repeated. Better than this, from the operational standpoint, are tapered split bushings that can be adjusted for wear throughout the life of the bushing, thus maintaining the accuracy of the machine for a long period of time. This type of bushing most nearly approaches the adjustment feature of the dovetail slide. Another approach to the wear problem is the use of linear type ball bushings on hardened shafts. However, careful analysis must be made of the brinnelling effect of the balls on the shaft, which on heavily loaded machines might require excessively large shafts.

Multiple bars as guides in a horizontal plane are used as rails for motors having variable or adjustable pitch sheaves, and in some belt tightening devices. Here no great degree of rigidity or accuracy of positioning is required. Low cost is essential and relative motion small. Guides of this kind are often neither hardened nor ground, and perform very satisfactorily. Several threading machines are, or have been manufactured with round bar guides. Here the problem of deflection becomes very serious because it spoils the alignment of the tool and the work. Some of these machines carry the work on a vise or clamp attached to a carriage riding on the round bar guides, while the die head revolves on a spindle, presumably lined up with the work. When large pipes are threaded on these machines, if they do not deflect the guides from their weight alone, they are bound to do so because of the 21 foot lever arm of a full length of pipe, resulting in torn threads and broken dies.

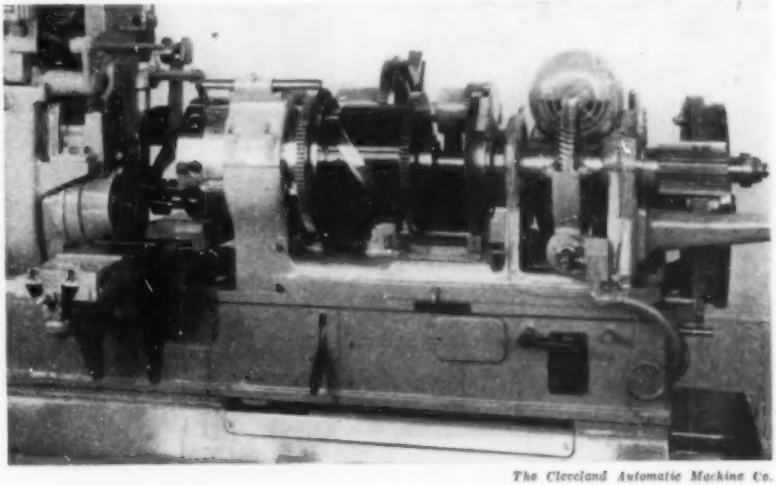
Another problem encountered on machines having multiple round guides is the tendency of the sliding element to "cock" between the guides. The greater the distance between the supports, the slimmer the columns; and the shorter the length of the bushings, the greater this problem becomes. Best results will be obtained with long bushings, preferably equal in length to the distance between the guide rods, with the center of the bushings relieved to clear the guide, except at its two ends. Failure to do this will cause excessive friction; and should the guide rods bend due to an eccentric loading, the machine would jam. Lengthening the bushings, of course, will increase the length between the guide rod supports for any given travel of the slide, thereby increasing the tendency of the guide rods to deflect. Thus, a compromise must be arrived at between the various factors involved.

A common and successful example of vertical round bar guides used in pairs are the guide pins and bushings on punch press die shoes. Here the



The Toledo Pipe Threading Machine Co.

Fig. 2—The weight and clamping strain of the pipe to be threaded in this machine is taken by the headstock without transmitting any of these loads to round bar guides.



The Cleveland Automatic Machine Co.

Fig. 3—The horizontal round bar is used for positioning the turret tools and feeding them into the work. The large diameter of the turret eliminates any posible deflection.

pins or bars are protected against excessive deflection and "cocking" by the guides or ways on the punch press, which are generally some form of dovetail machined into a massive frame of cast iron or steel plate. The costs of maintaining the required close tolerances required on the pin guides of the die shoes is reduced to a minimum because of the large volume of parts produced, thus justifying the best in tooling and production methods. The arbor support is thus in line with the spindle and prevented from rotating about the center line of the bar.

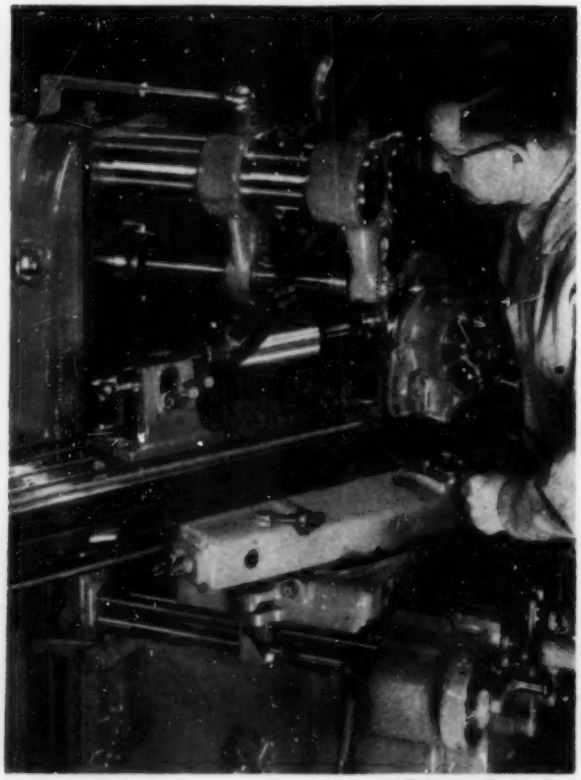
Another good example of vertical round bar guides is in the strain rods or side members of a hydraulic press, Fig. 5. In this case the bending of the guides is restricted by the fact that the rods are under a tension load during the working stroke. Unless the bushings are particularly long, trouble with cocking is sometimes experienced, particularly on two post presses. Care must be taken in setting dies in the press so that the center of resistance of the die is directly under the ram of the press.

A problem arises when this type of press is used with heated platens, such as in the plastics industry. The upper and the lower plattens expand from the heat, while the header of the press does not, throwing the strain rods or guides out of parallel. This can be controlled by heating the header, by allowing for lateral movement of the strain rods where they attach to the header, or by allowing sufficient clearance between the guides and the bushings of the movable platen to allow for the different center to center distances of the strain rods because of temperature differences of the two platens and the header of the press.

The first solution is the most satisfactory, although it increases first cost, maintenance, and cost of operation. Furthermore, if platten temperatures are high, they may adversely affect the life of hydraulic cylinder packing. The second and most common solution is a good compromise, although it reduces the overall rigidity of the press. The third solution is least desirable in that it greatly increases the possibility of trouble from "cocking", movable platen chatter, and mismatch of dies.

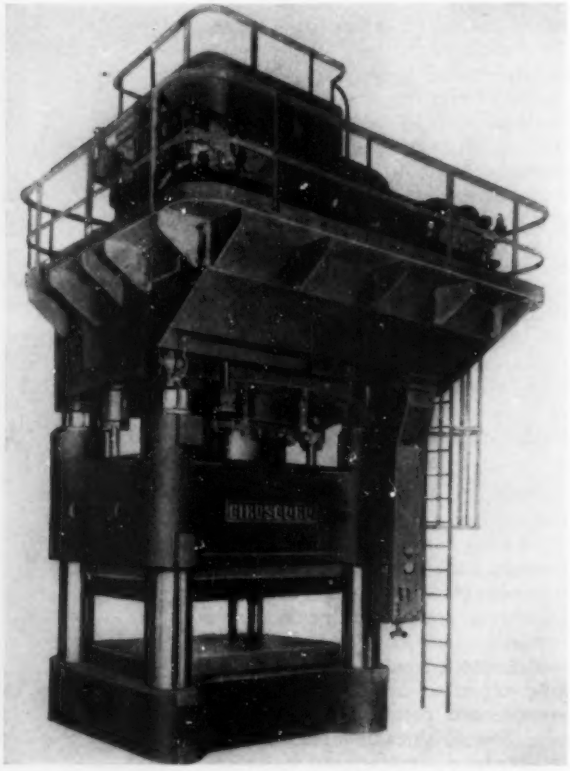
In spite of these problems, some of which are also found in dovetail guided presses, there is no cheaper way of building a press of this type, as can easily be seen by comparing the material cost and machine work required on a round bar press guide, with the massive cast iron or steel columns with their machined ways that would be required in any variation of the dovetail guide principal. Of course, the cast iron or built up steel press would have a much longer life expectancy.

It is essential in designing round bar guides to consider any force that might cause deflection of the guides, and either design them sufficiently large in diameter and short in length to resist those forces, or place the guides in such a way that minor deflections do not change the relative position of the tool and work. Where the forces involved are torque about a spindle, and thrust through the spindle center line, the best arrangement is to place the guides equi-distant from the spindle on a horizontal line drawn through the spindle center-line, with the power source that moves the carriage as close to the center line of the spindle as possible. Guide rods in a horizontal position tend to wear much faster on the top surface because of the weight of the carriage and the dirt and chips and may have to be replaced more often than similar rods in a vertical position.



Kearney & Trecker Corp.

Fig 4—The use of the two parallel bars instead of the more common single round bar gives a solid support for the end of the arbor. Replacement of both pins and bushings that have become excessively worn is available from a ready supply.



Birdsboro Steel Foundry & Machine Co.

Fig 5—This 4-post hydraulic press typifies the savings in construction costs made possible by the use of round bar guides. As a general rule, in press design, the smaller the press, the greater the saving when taken as a percentage of total construction cost.

The Hysteresis Motor for Synchronous Power

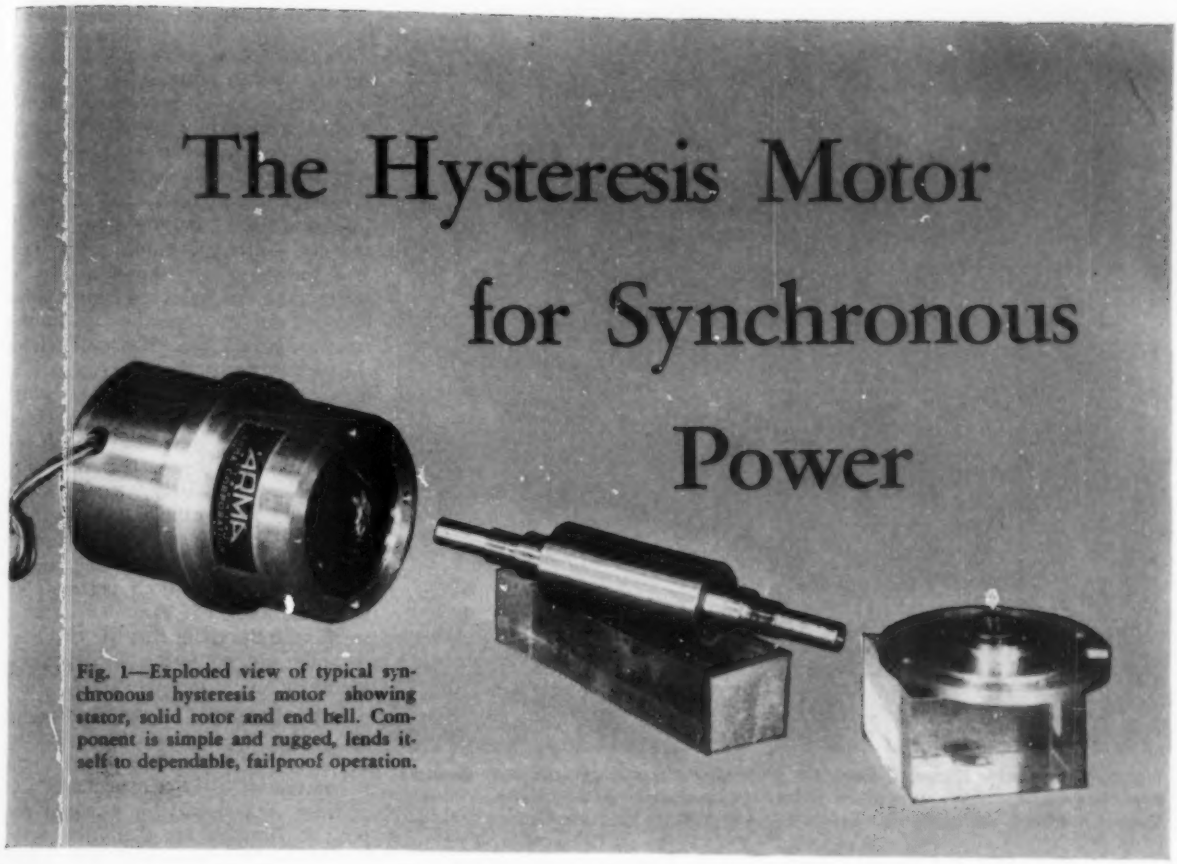


Fig. 1—Exploded view of typical synchronous hysteresis motor showing stator, solid rotor and end bell. Component is simple and rugged, lends itself to dependable, failproof operation.

Although up to now they have been found mainly in electric clocks, improved synchronous hysteresis motors are at present being used to power many types of constant torque or high inertia loads in industrial and military applications.

SIDNEY DAVIS
Research Group, Arma Corporation
Brooklyn, N. Y.

THE SYNCHRONOUS hysteresis motor is a simple, rugged unit which is distinguished from other types of synchronous motors in that it is capable of developing high starting torque and synchronizing high inertia loads without complicated starting and accelerating equipment.

Until recently the inferior qualities of available magnet steels limited the motors usefulness; and applications were restricted to devices requiring negligible power, such as electric clocks. With the introduction of the improved chromium, tungsten, and cobalt steels and later the Alnicos, these limitations were overcome and the hysteresis motor is now being used as the power unit in timing devices, gyros, tension drives, stroboscopic devices, phonographs, wire recorders, and sound cameras and projectors. Commercially available units range in size from a fraction of a watt (or negligible) output to about 100 watts. A few larger units have been built; with specially designed hysteresis motors being capable of supplying very high intermittent outputs.

In addition to its torque characteristics, the hysteresis motor has other features which may interest a user. The perfect symmetry of the rotor construction means complete freedom from the cogging affects common in most other types of motors. The quietest of all motors, it is ideally suited to use in phonographs. Its shaft torque, and input current and power vary little from standstill to synchronous speed and it is relatively free of undesirable hunting.

Magnetic Materials

Since the hysteresis motor develops torque as a result of the residual flux in the rotor steel, a description of the theory of motor operation is best preceded by a review of the properties of magnetic steels.

These steels are usually classified as either soft or hard. The soft class is characterized by high permeability and low losses in varying magnetic fields. It is used in the cores of electrical machines and devices, where flux must be confined to a restricted path. Most familiar in this group are the silicon steels, Mumetal, Hypersil, etc. Hard magnetic steels find their principle application in permanent magnets. They are distinguished by their large hysteresis loops. While very high magnetomotive forces are required to magnetize them, they retain a good portion of their flux even after the removal of excitation. In Fig. 2 is shown a comparison of the hysteretic characteristics of a soft and a hard steel.

The approximate relationship between flux and current in a simple magnetic circuit with a hard steel core and sinusoidal applied voltage is

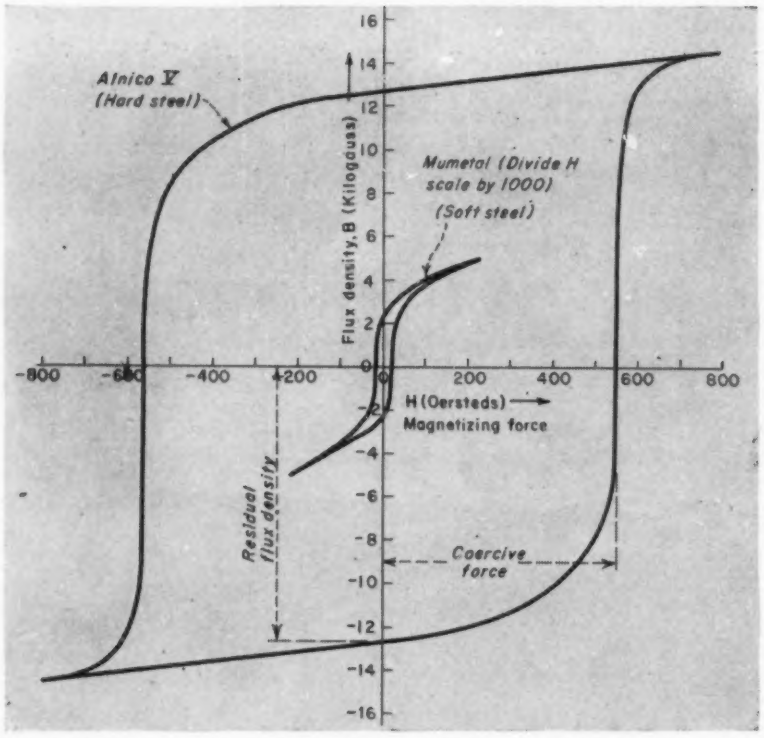


Fig. 2—Comparative hysteresis loops for a soft and a hard magnetic steel. Residual flux density and coercive force are defined by notations on the Alnico V curve. Magnetizing force scale must be divided by 1000 for soft steel Mumetal.

shown in Fig. 3. The flux variation is closely sinusoidal when the applied voltage is sinusoidal. A point by point plot traced out around the hysteresis loop, starting at arbitrary zero time, shows that the waveform of the magnetizing current is highly distorted, and that the flux density wave lags the fundamental component of the magnetizing current by an angle which is characteristic of the hysteresis loop. The motor develops torque as a result of this time lag. The value of the torque is closely related to the area of the hysteresis loop, or, to what is equivalent, the hysteresis loss per cycle. The newer permanent magnet materials, having much larger loop areas than the early carbon steels, permit increased efficiency and outputs. The table compares the characteristics of some popular magnetic materials.

How Torque is Developed

A three-phase hysteresis motor is shown schematically in Fig. 4. The unit consists of a conventional stator, with a cylindrical ring of permanent magnet steel mounted on a nonmagnetic support for the rotor. Connecting the stator to a balanced three-phase line sets up a rotating mmf which induces a magnetization in the hard steel rotor ring. As shown in Fig. 3, the rotating flux field will lag the mmf by some angle, depending upon the rotor material. Fig. 5(A) illustrates the instantaneous flux and current in the air gap of a hysteresis motor, while Fig. 5 (B) shows the same machine with a soft steel rotor ring. With the hard steel rotor the instantaneous flux axis, ϕ, lags the instantaneous stator mmf axis, M, by a finite angle, ψ, and torque will be developed depending on the magnitude of the lag angle. In the case of the high permeability soft steel rotor, the hysteresis effect is small with the result that the two axes coincide and no torque is developed by the motor.

While operating below synchronous speed the flux-current pattern in the air gap is independent of speed. This is equivalent to saying that stator impedance is independent of speed for positive slips, as are therefore stator current, power, and power-factor. The power transmitted from stator to rotor is also constant below synchronism and may be calculated at standstill for all speeds in this range. But the power of the rotor at standstill is the hysteresis loss developed in the rotor, which can be calculated from:

$$W_r = kfVA$$

where

f = line frequency
V = volume of hard steel of rotor

Materials	Coercive Force (Oersteds)	Residual Flux (Kilogauss)
1 percent carbon	48	8.6
3½ percent chrome	63	9.0
6 percent tungsten	72	10.0
Alnico II	560	7.35
Alnico IV	730	5.3
Alnico V	575	12.5
Cunico	710	3.4

Hysteresis characteristics of some permanent magnet steels. The Alnicos have highest strengths.

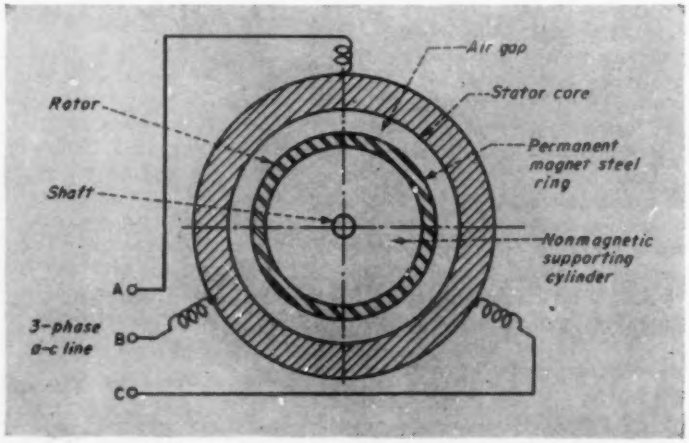


Fig. 4—Schematic of three-phase hysteresis motor. Stator is standard polyphase type, while the rotor is a cylinder of laminated or solid magnet steel.

f = area of hysteresis loop of rotor material

W_r = rotor hysteresis loss at standstill

k = constant depending upon the system of units.

For a constant amplitude of alternating magnetization, hysteresis loss is proportional to frequency. Therefore, at slip, s, greater than zero, the loss is sW_r. However, as previously noted, rotor power is a constant, W_r. The power difference $W_r\ (1-s)$ must therefore be the power developed at the shaft. Since rotor speed is proportional to $(1-s)$, shaft torque must be a constant. The numerical value can be calculated by dividing $W_r\ (1-s)$ by speed in a consistent set of units.

From the previous discussion it would seem that the upper torque limit available in a given motor volume would be exclusively determined by the magnetic characteristics of the active rotor material. With strong materials such as Alnico V, very high torques might then be generated. Unfortunately, there is another limitation, in that stator ampere turns must be sufficient to provide the necessary degree of magnetization. For Alnico V the stator current might be excessively high. Usually a medium strength magnetic material is selected in an attempt to balance output requirements against allowable heating.

The most commonly used steels in better hysteresis motors are 3½ percent chrome steel, and 35 percent cobalt steel. The latter can provide about 5 to 10 times the power, per cubic inch of active rotor steel, as the former. Each may have its strength reduced below maximum by soaking at various temperatures after hardening, and thus, between them, they provide a wide range of available strengths.

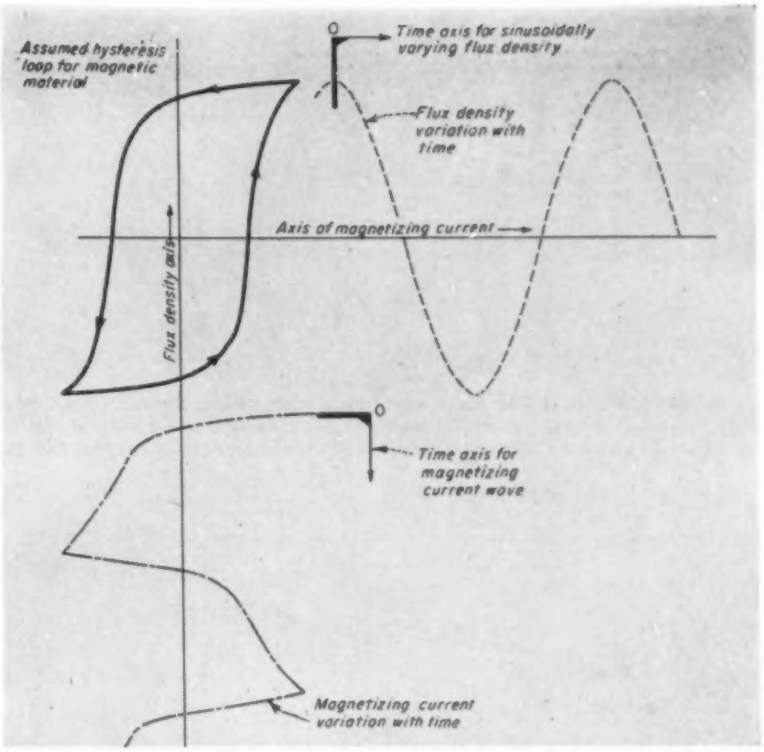

Assumed hysteresis loop for magnetic material
Flux density axis
O
Time axis for sinusoidally varying flux density
Flux density variation with time
Axis of magnetizing current
O
Time axis for magnetizing current wave
Magnetizing current variation with time

Fig. 3—Plot of flux density and magnetizing current against time, starting at an arbitrary zero time. The flux density lags the magnetizing current by an angle resulting from the hysteretic nonlinearity. Note the distortion of the magnetizing current curve.

At synchronous speed, the rotor and the rotating stator field have zero relative velocity. Rotor magnetization lags the stator mmf by an angle analogous to the power angle of a conventional synchronous motor. Unlike the conventional synchronous machine, a steady rotor field is induced in the permanent magnet rotor ring, rather than applied by a special d-c winding. The lag angle varies with shaft torque, and is zero when total torque (including friction, windage, and stray electrical losses) is zero. The maximum synchronous torque equals the torque generated just below synchronism, as previously calculated. The hysteresis motor hunts; however, rotor losses tend to damp out oscillations.

The pulling-into-step transients usually associated with synchronous machinery do not exist in the hysteresis

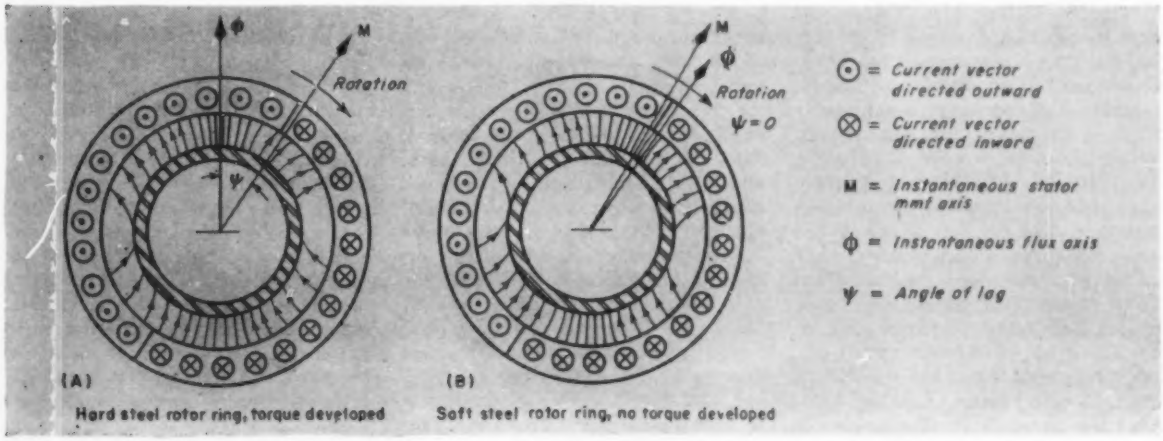


Fig. 5—(A) Hysteresis affect of hard steel rotor ring causes the flux axis to lag the stator mmf axis by an angle, ψ. A resultant rotor torque is developed. (B) High permeability of soft steel causes axes of current and flux to coincide; no torque developed.

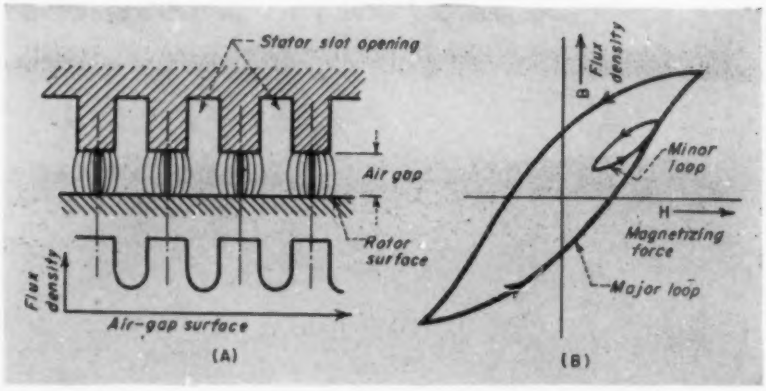


Fig. 6—(A) Variation of flux density along the air-gap surface, showing ripple introduced by stator slot openings. (B) Because of the variations in gap density, the active rotor material will not follow the simple major loop, but may trace out minor loops.

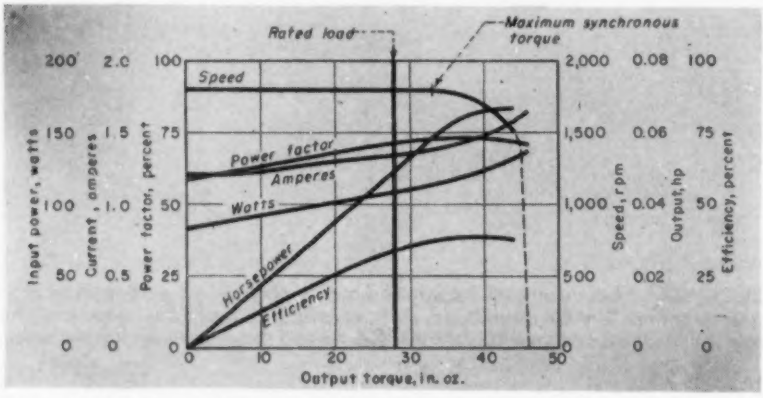


Fig. 7—Typical hysteresis motor starting characteristics with solid rotor ring. Eddy currents and resulting induction motor torques cause torque, current, and power to vary as shown. With laminated rotor these factors are independent of the motor speed.

motor. The uniform torque developed right up to zero slip can synchronize smoothly any load whose losses it can carry. This is an important feature for high inertia loads.

Practical Design Factors

The preceding discussions assumed idealized conditions, namely sinusoidal mmf distribution around the air gap, and perfect circular symmetry. These do not exist in an actual machine.

Stator slot openings introduce a ripple in the air gap flux pattern, subjecting the rotor iron to a pulsating magnetization. With a sufficiently wide pulsation amplitude, rotor magnetization does not follow the simple hysteresis curve of its material, but traces out minor loops, which effectively reduce the major loop area, causing a reduction in torque, Fig. 6. A serious loss in efficiency results unless the slot openings are made very small, thereby boosting winding costs. A peculiar feature of this sensitivity to flux pulsation is the fact that frequently efficiency can be increased by increasing the air gap. The larger gap has a cushioning effect on the irregularities in gap reluctance caused by the open slots. Motors with slot openings comparable to those in induction machines require unusually large air gaps to reduce parasitic losses to a reasonable value. This means high stator copper losses and poor efficiency.

Another type hysteresis motor permits economical manufacture with closed slots, thereby minimizing this source of stray losses. In this design, the smooth air gap can be made very small, thereby reducing the required stator current. Power formulas based upon the simplified theory assumed above hold adequately here. Unfortunately, closed slots increase stator leakage reactance and substantially decrease power factor.

In addition, the stator is responsible for another parasitic loss. Its finite number of slots prohibit ideal winding distribution, and rotating fields of harmonic mmfs are set up just as in an induction motor. These exert the same deleterious effects on efficiency as do the slot pulsations, and can only be minimized by resorting to expensive windings having many slots. Careful design can keep losses from this source down to a reasonable value.

While starting, a hysteresis motor having a solid rotor ring will develop eddy currents in the ring and consequently induction motor torques. These are in addition to the hysteresis torque. Thus, torque, current, and power are not independent of speed but vary somewhat in the manner of Fig. 7. This effect may be neglected when the rotor is laminated.

Since the relationship between developed power and air gap flux is highly nonlinear, the hysteresis motor should be operated at close to its rated voltage and frequency. A percentage loss of line voltage may cut power output by two or three times that percentage. To minimize parasitic losses, the waveform of the supply must be good. Maintenance of good waveform is not simple inasmuch as the hysteresis motor draws a highly distorted line current.

Types of Motors

There are three general groupings of commercially available hysteresis motors, roughly classified according to efficiency:

(1) Units having efficiencies under 1 percent are usually available heavily geared down. They find application in a large variety of timing devices including electric clocks. Their construction aims primarily at economy, and parisitic losses are many times the useful output. The cost may be much less than the cost of an equivalent shaded pole motor. They can be obtained for operation on up to 440 volts at 60 cycles. Some manufacturers can also supply models for 25 cycles and other frequencies. This type unit is available from R. W. Cramer Co. and various clock manufacturers.

(2) Units of intermediate efficiencies of from 5 to 25 percent are applied widely in phonographs, where the freedom from hunting and *wow*, the low noise, and the ability to synchronize the high inertia of the turntable make the hysteresis type motor ideal. These units are more efficient than the reluctance synchronous motor, and require no special damper windings for starting. They are somewhat higher in price than a conventional induction motor. One manufacturer is Eastern Air Devices, Inc.

(3) There are also the closed slot variety of hysteresis motors which have efficiencies ranging up to 75 percent at 60 cycles, although the normal range is from 20 to about 45 percent.

At 400 cycles, efficiencies tend toward the higher limits, and in specially designed gyro motors may exceed 80 percent. These units are normally used in the same sort of applications as those of Group (2), but they supply greater output in a given frame. They roughly compare in cost with high quality a-c servo motors, and may be obtained from the Fairchild Camera and Instruments Corporation.

The hysteresis motor may be operated from a polyphase line, or from a single-phase line as a capacitance motor, as a shaded pole motor, or in any of a variety of ways similar to a single-phase induction motor. However, high efficiency and output are only possible when the stator mmf field rotates uniformly as an ideal polyphase field. Thus, a hysteresis machine exhibiting induction motor torques below synchronism, and adjusted to operate efficiently as a capacitance motor at synchronism, may lose starting torque due to the changing impedence and consequent unbalance of the capacitance phase for slips greater than zero. The balanced capacitor unit usually operates at a slightly lower efficiency than the straight polyphase unit because of the effects of nonlinearities and harmonics. Likewise, the poor waveforms associated with the shaded pole type of motor subtract substantially from its efficiency, although low efficiency hysteresis motors frequently use this starting arrangement.

The efficiency of the units included in Groups (2) and (3) can be increased from 5 to 30 percent by temporary overexcitation. Thus, if the line voltage to a synchronized unit is increased momentarily by 20 percent or more, and then returned to its rated value, a permanent magnetism will be induced in the rotor which will permit the unit to carry additional load at reduced exciting current, thereby increasing efficiency.

Increased output can vary from 10 to 20 percent to over 50 percent by overexciting. This varies with the design; especially with the normal degree of saturation of the rotor iron. Momentarily desynchronizing the rotor will remove this effect, but the procedure may be repeated.

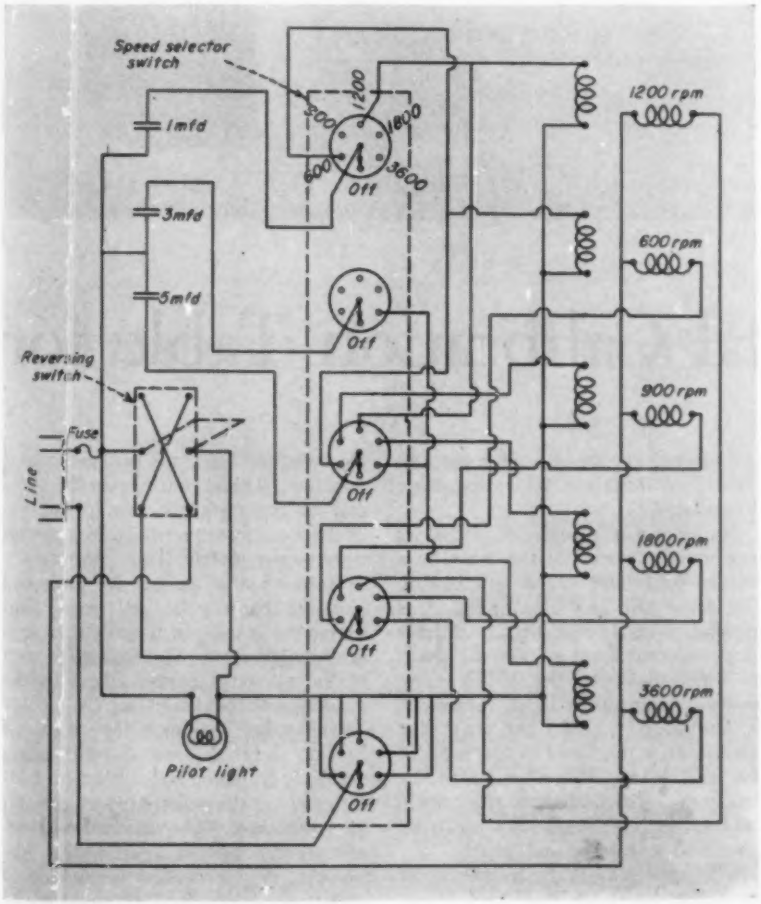


Fig. 8—Diagram for five-speed a-c capacitor motor with arrangements for reversing and speed switching. Output varies from 3.5 watts at 600 rpm to 20 watts at 3,600 rpm.

Speed Control

Multi-speed hysteresis motors are available which operate at several synchronous speeds. External switching devices are used to reconnect the windings in various pole groupings thereby changing the motor speed. The Electric Indicator Co. has a unit, Fig. 8, which can deliver from 3.5 to 20 watts in speeds of 600, 900, 1,200, 1,800 and 3,600 rpm; the lower output applying at the lower speed.

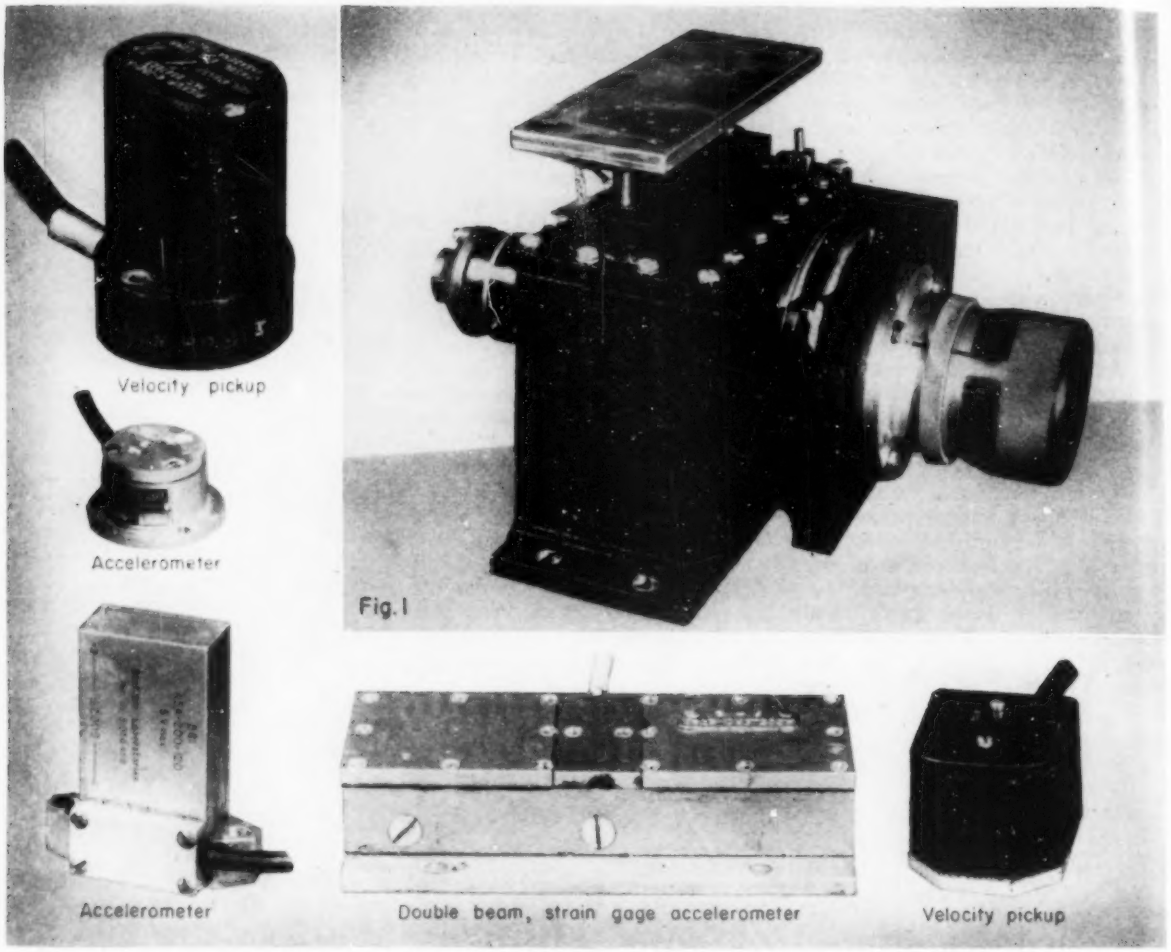
Adjustable-speed hysteresis motors operate at varying speeds by changing the supply frequency. If the ratio of applied voltage to frequency is maintained constant (implying constant flux density in the magnetic circuit) the developed torque will be approximately constant although the power output will vary linearly with frequency and speed. Input power increases with frequency because of increasing core losses.

This type component can be used to measure the linearity of precision tachometers. Supply frequency is adjusted to form stationary Lissajous patterns on an oscilloscope with a reference frequency, and the synchronous speed can be exactly calculated. The small amount of hunting which occurs with a hysteresis motor makes it ideally suited to this application.

How Cost Compares With Other Types

Although the cost of the better hysteresis motors is somewhat higher than comparable induction motors, it is probable that given sufficient time and more widespread production, the price gap can be reduced. Improved production development of the closed slot stator construction, plus the simple rotor design should permit this eventual cost reduction. It should be pointed out that its unusual properties may make the hysteresis motor desirable even when substantial output power is not required. For this reason, economic rather than theoretical considerations frequently determine the efficiency, thereby accounting for the wide range of values.

The field for hysteresis motors continues to expand. The constant torque characteristic is suited to tensioning devices and couplings. Its performance is superior to that of the reluctance motor, and the latter's cogging effects are avoided. The ruggedness and simplicity of the motor have made it useful in military equipment, especially high inertia gyros. As the knowledge of its properties becomes more widespread, its fields of application will probably be further extended.



Sinusoidal Calibration Table for

CARLETON M. FIELDS
Senior Vibrations Test Engineer

ROBERT S. NEVIN
Senior Instrument Engineer
The Glenn L. Martin Company

ENGINEERS REQUIRE many types of instrumentation to check the equipment they design and to obtain data that are used in theoretical analysis. These instruments too must be checked and calibrated to discover inaccuracies in the data they yield.

Transducers for measuring acceleration, velocity, and displacement of the motion of parts during vibration are shown above. To calibrate the readings of such vibration transducers, The Glenn L. Martin Company designed and constructed the sinusoidal calibration table shown in Fig. 1. The design permits holding or changing the amplitude of vibration while the table is oscillating.

Harmonic or sinusoidal oscillatory motion is imparted to the table by a Scotch yoke and crank mechanism. The crank pin, as shown in Fig. 2, is integral with a block that is slidable in the slotted head of a quill shaft, to which is keyed the V-belt drive pulley. A pin in the block is engaged by one slotted leg of a bell crank that swivels on a pin fixed in the head of the quill shaft. The other leg of the bell crank, also slotted, engages a pin held in the inner end of a push rod contained within the quill shaft.

With this linkage, the eccentricity of the crank pin is variable. Any lateral displacement of the push rod relative to the quill shaft causes an equal displacement of the crank pin in a radial direction. Thrust bearings on the outer end of the push rod are locked between a micrometer head and a micrometer screw sleeve. Thus, turning the micrometer head moves the push rod laterally, swivels the bell crank, and moves the crank pin radially to a new eccentric position. One complete turn of the micrometer head displaces the crank pin 0.1 in. radially.

The yoke, in which the crank-pin bearing slides, is constrained to move vertically by guide rods. Vertical rods fastened to the yoke support the instrument table. The maximum excursion of this table is 1 in. double amplitude. Any excursion from zero to maximum is obtained by positioning the micrometer, the head of which is graduated in thousandths of an inch.

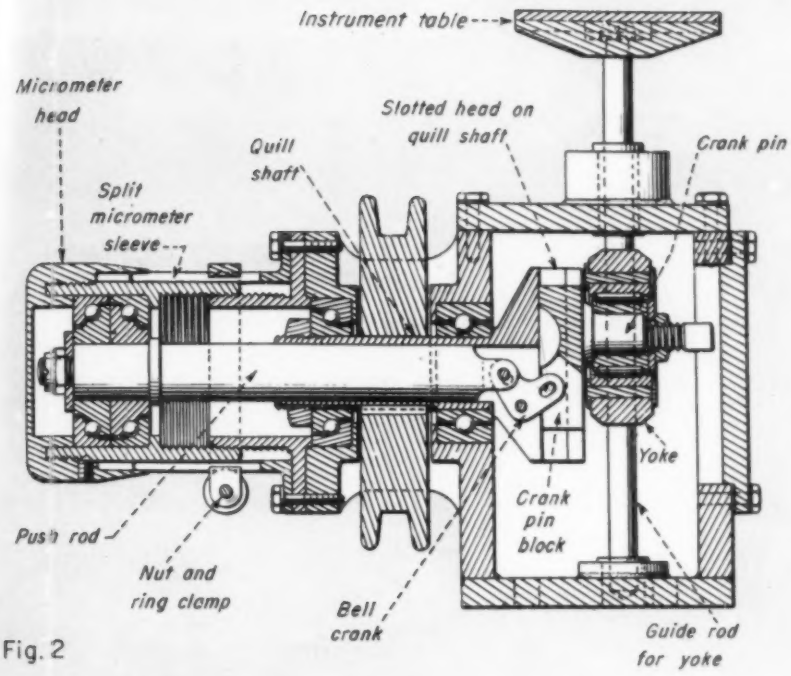


Fig. 2

Fig. 1 – Sinusoidal calibration table. Amplitude and frequency of vibration can be changed while table is oscillating. Scotch yoke and crank mechanism impart harmonic motion to the table. The table is used to calibrate instruments that measure acceleration, velocity and displacement of vibrating structures and equipment.

Fig. 2 – Arrangement of parts in the sinusoidal calibration table. A lateral displacement of push rod displaces the crank pin radially an equal amount. The table is belt driven; its frequency of oscillation can be varied or adjusted by using a variable speed motor drive or a constant speed motor driven speed changer.

Vibration table for dynamically calibrating acceleration, velocity, and displacement type transducers. The device can also be used to check equipment that in service is vibrated at variable accelerations at constant frequency or with constant acceleration at variable frequency. Scotch yoke mecchanism gives harmonic motion to table.

Vibration Type Transducers

A ring and lock-nut on the split micrometer sleeve prevents any lateral movement of the push rod after the micrometer is set.

The table being belt driven, its frequency of oscillation can be varied or adjusted by using a variable speed motor drive or a constant speed motor drive coupled to a variable speed changer. An extension on the crank pin can be used to drive a tachometer to read the frequency of the table oscillations.

For a calibration test, the instrument to be calibrated is fastened to the table and readings of the instrument are taken and checked against the known settings of the oscillating table.

The peak amplitude, velocity, or acceleration developed by the sinusoidal motion of the table are given by the following harmonic vibration relations.

Where

- A = single amplitude, the eccentricity of the crank pin indicated by the micrometer, in.
- f = frequency as given by the tachometer, cycles per sec
- t = time, sec
- x = displacement of table for mid-position at any instant of time, in.
- v = velocity of table at any instant of time, in. per sec
- a = acceleration of table at any instant of time, in. per sec per sec

the peak displacement x_m, of course, is

$$x_m = A$$

Since $x = A \sin (2 \pi ft$, radians)

the velocity v of the platforms at any instant of time is

$$v = \frac{dx}{dt} = 2 \pi f A \cos (2 \pi ft)$$

and the peak velocity v_m occurs when

$$\cos (2 \pi ft) = \pm 1$$
$$v_m = \pm 2 \pi f A$$

The acceleration a at any instant of time is

$$a = \frac{dv}{dt} = -A(2 \pi f)^2 \sin (2 \pi ft)$$

and the peak acceleration a_m occurs when

$$\sin (2 \pi ft) = \pm 1$$

or

$$a_m = \pm A (2 \pi f)^2$$

In addition to its use for calibrating vibration type transducers, the table can be used to check electronic and other types of equipment that in service are vibrated at variable accelerations at constant frequency, or at constant acceleration at variable frequency.

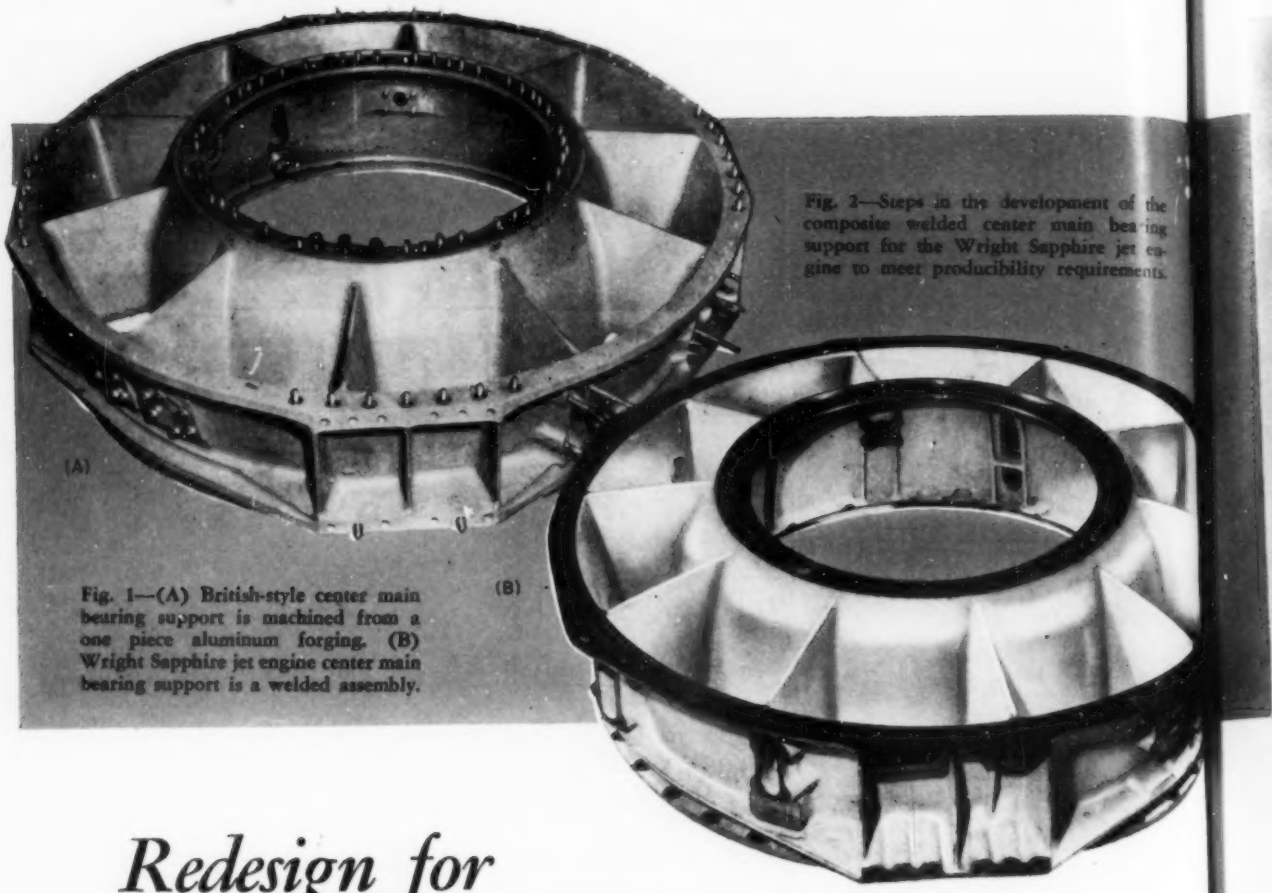


Fig. 1—(A) British-style center main bearing support is machined from a one piece aluminum forging. (B) Wright Sapphire jet engine center main bearing support is a welded assembly.

Fig. 2—Steps in the development of the composite welded center main bearing support for the Wright Sapphire jet engine to meet producibility requirements.

Redesign for

Producibility Based on

LATE IN 1950 two Sapphire engines pushed a Gloster Meteor 8 airplane up to 30,000 feet in 181 seconds. This feat stimulated American interest in the Sapphire. A straight-through turbo-jet engine, the Sapphire was developed by Armstrong Siddeley Motors Ltd. from an original design by Metropolitan Vickers, Ltd. Under a long-term engineering and production agreement, the Sapphire is now being produced in the United States by the Wright Aeronautical Division of the Curtiss-Wright Corporation.

The Wright Sapphire J-65-W-1 is flying one of the fastest fighter planes in the world; the performance figures are still secret. Meagre published data, however, indicate that the engine is about 11 ft long, weighs 2500 lb, and develops 7200 lb thrust at sea level.

The full thrust is taken by the center bearing support of the engine. The outer ring of this support is attached to the aircraft frame, and to engine parts, fittings, and housings. The inner ring of this support encloses the main bearing of the engine shaft. Several radial struts connect the inner and outer rings so that air can flow between the rings.

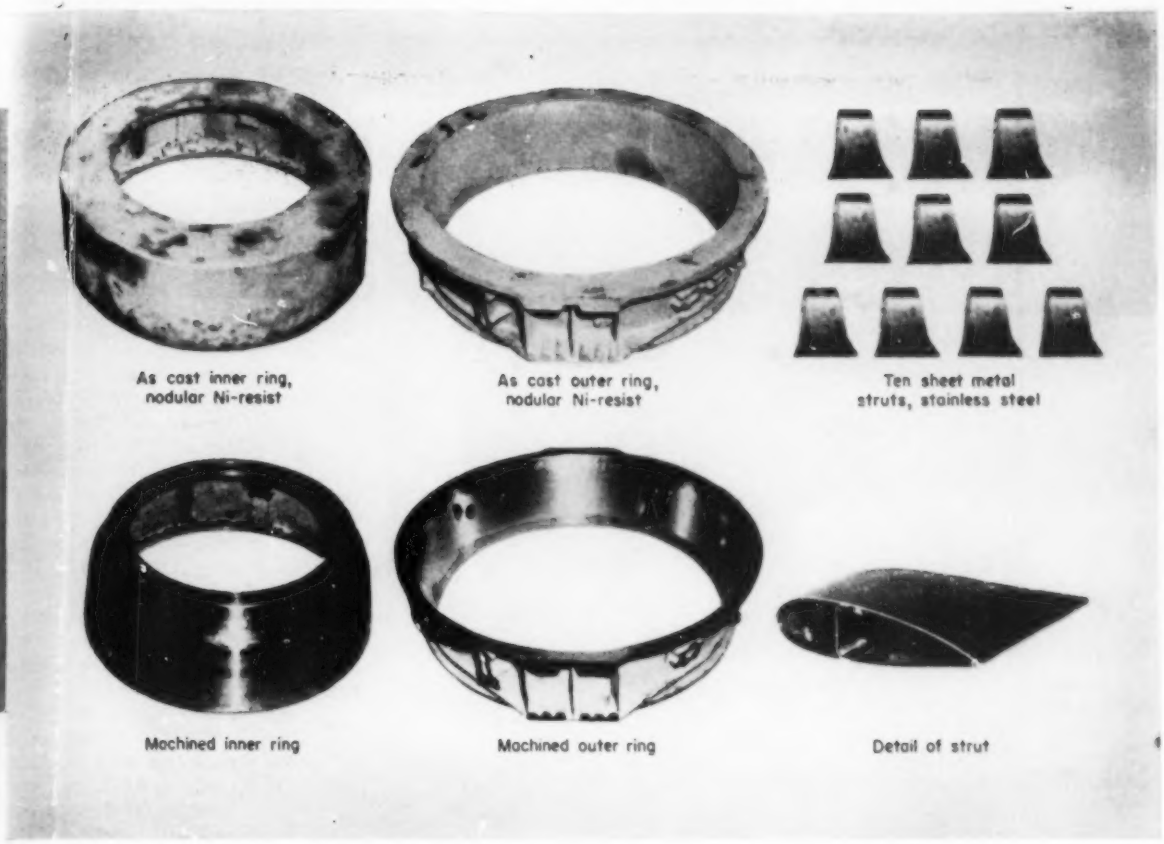
The British-style center bearing support, Fig. 1 (A) is machined from a one-piece aluminum forging 38 in. in diameter and 11 in. thick; it weighs 1575 lb. Fabrication is accomplished on a Keller duplicating machine using three dimensional contour milling. About nine pounds of chips are produced for a pound of finished product. An analysis of the British experimental method estimated the cost of producing the British center bearing support to be $5,700 in the United States using a contoured forging.

Requirements for producibility, as set up by Curtiss-Wright engineers, could not be met using Kellering equipment. Time estimates for the Kellering operation alone on this part ran from a high of 1200 to a low of 700 hours. On this basis, one duplicating machine operating three shifts would produce less than one unit a month. This method, obviously, was not a practical mass-production procedure. U. S. A. F. requirements also imposed higher top operating temperatures and greater peak stresses than those for which the British part was designed to withstand.

To get the Sapphire engine into production, the need for producibility and greater strength at elevated temperature called for a complete redesign of the center bearing support that would:

1. Avoid the complex Kellering operation.

2. Replace the aluminum alloy with materials having greater strength at elevated temperatures.


As cast inner ring, nodular Ni-resist
As cast outer ring, nodular Ni-resist
Ten sheet metal struts, stainless steel
Machined inner ring
Machined outer ring
Detail of strut

New Welding Technique

Technique for welding stainless steel parts to modified nodular cast iron as developed in redesign of center main bearing support for the Wright Sapphire turbo-jet engine.

3. Establish a fast and economical production method.

A study to provide for greater latitude in manufacture indicated that the part could be readily redesigned into three major components: Inner ring; outer ring; and struts.

In this redesign stage, costs were estimated on the basis of high production, assuming that casting problems could be overcome and that normal scrap allowance could be maintained. These estimated costs for one assembled center support were:

Castings and machining...	$898
Struts	20
Welding	25
Total	$943

This estimated cost is less than 10 percent of the estimated cost of producing the center bearing support as designed and produced experimentally by the British.

Further study revealed that the selection of material for the rings, the development of foundry techniques to produce castings having the qualities desired, and the development of a satisfactory welding method, were far more complicated than designing a composite part made up of three elements.

Investigations and development projects, however, were undertaken to overcome these obvious difficulties; the result was the evolution, as shown in Figs. 1(B) and 2, of a composite assembly redesigned from a single forging.

The inner and outer rings are made from castings. Ribs, flanges and bosses are placed only on the inner surface of the inner ring, and only on the outer surface of the outer ring. The outer surface of the inner ring and the inner surface of the outer ring are machined to smooth contoured surfaces in simple turning operations with little difficulty.

The struts are made from stainless sheet steel and fabricated as single components.

To form one assembly, the struts are welded to the outer surface of the inner ring and to the inner surface of the outer ring.

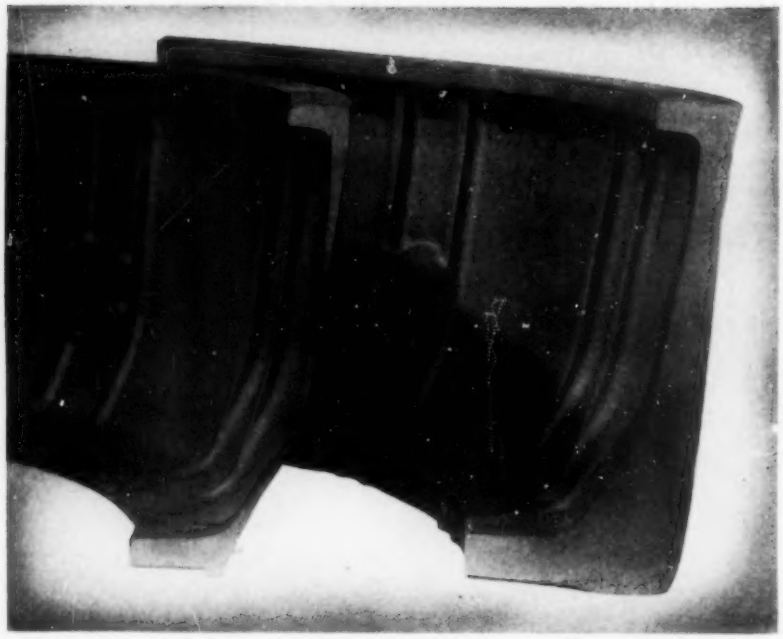


Fig. 3—Sections of the inner ring with a precision cast inner surface. (Right) "As-cast" before machining outer surface of the casting. (Left) After machining outer surface.

Selection and Development of Ring Material

Successful use of cast rings called for a weldable material and a foundry process that could make castings having one complex irregular surface held to extremely accurate tolerances. This complex surface had to be held close enough "as-cast" so that a reasonably uniform wall thickness could be produced by one simple turning operation on the other surface of the casting.

In addition to the high strength needed at elevated temperatures, the material in the center main support bearing required a coefficient of expansion compatible with that of the aluminum compressor housing and the stainless steel burner housing, which are bolted to either side of the outer ring.

A survey of possible materials showed a rather limited selection. Cast steels have sufficient strength, ductility and weldability for the ring parts, but could not be cast to the complexity and dimensional accuracy required. Gray irons, although having satisfactory casting characteristics, lack strength and ductility. Nodular ferritic cast iron, because of its excellent casting characteristics and good mechanical properties, at first appeared to be a suitable material. Subsequent investigation showed that the nodularizing treatment required for the ferritic material produced dimensional changes that could not be tolerated on the "as-cast" surfaces. In addition, the relatively low coefficient of expansion of this material would introduce further design problems. Intensive development work, however, is continuing on the casting, welding, and modifications necessary for ultimate use of the ferritic grade. With the likelihood that problems inherent in the ferritic material can be solved.

Austenitic nodular cast iron appeared so well suited for the rings that such an alloy containing about 20 percent nickel could be justified. To obtain all the properties desired, however, some modifications of composition were made and a special austenitic cast iron was developed in collaboration with the American Brake Shoe Company. As experience was gained, the following modified Nodular Ni-Resist analysis was evolved:

	Percent
Carbon	2.7 to 3.3
Manganese	1.9 to 2.5
Silicon	2.2 to 3.2
Phosphorus	0.15 max
Sulphur	0.05 max
Nickel	21 to 26
Chromium	0.05 max
Molybdenum	0.30 max

In addition to the problem of composition, it was apparent that ordinary foundry practice would not result in the dimensional accuracy required. American Brake Shoe had already developed a precision casting technique for parts of comparable size, but this process had been applied only to the manufacture of cast iron molds for automobile tires and possibly would not be adequate where high quality castings are essential. With this process as a starting point, technique was deveolped for producing a sound casting having one precision cast surface with wall sections held to a tolerance of ± 0.030 inch.

A section of the inner ring as cast by this technique and after machining is shown in Fig. 3. The complex surface is used "as cast" in the finished part.

On the basis of cost, weight to strength ratio, material soundness, dimensional accuracy of wall thickness, surface finish and weldability, struts fabricated of sheet metal were favored when compared with shell castings. The final design of the strut called for sheet metal fabrication with AMS 5510 stainless steel.

Metallurgically, the disadvantages of nodular cast iron struts were sharply defined. The thin wall sections of the casting cool too rapidly and result in an unsatisfactory nodule formation, lack of stability, and decreased ductility. In addition, and definitely the most important factor, material as thin as the strut wall could not be satisfactorily welded.

High strength fillet welding of nodular cast iron was without precedent. (see "Ductile Iron," W. C. Mearns, *The Welding Engineer*, Nov. 1951) To develop a technique for welding the sheet steel struts to the nodular cast iron rings to produce a strong composite unit, an investigation was conducted to evaluate the inert gas shielded metal arc process and the manual metal arc process.

Preparation and Types of Weld Specimens

TYPE I AND II SPECIMENS. These simple specimens were used for preliminary evaluation. They are tensile specimens made from sections about $\frac{3}{8}$ in., thick cut from a weldment of stainless plate to a nodular cast iron base, as shown in Fig. 4(A). Type I, Fig. 4(B), was used for short time tensile tests at room temperature, and Type II, Fig. 4(C), for tests at elevated temperatures.

These specimens were a usable approximation of the weld required. The actual weld on the part is a single fillet

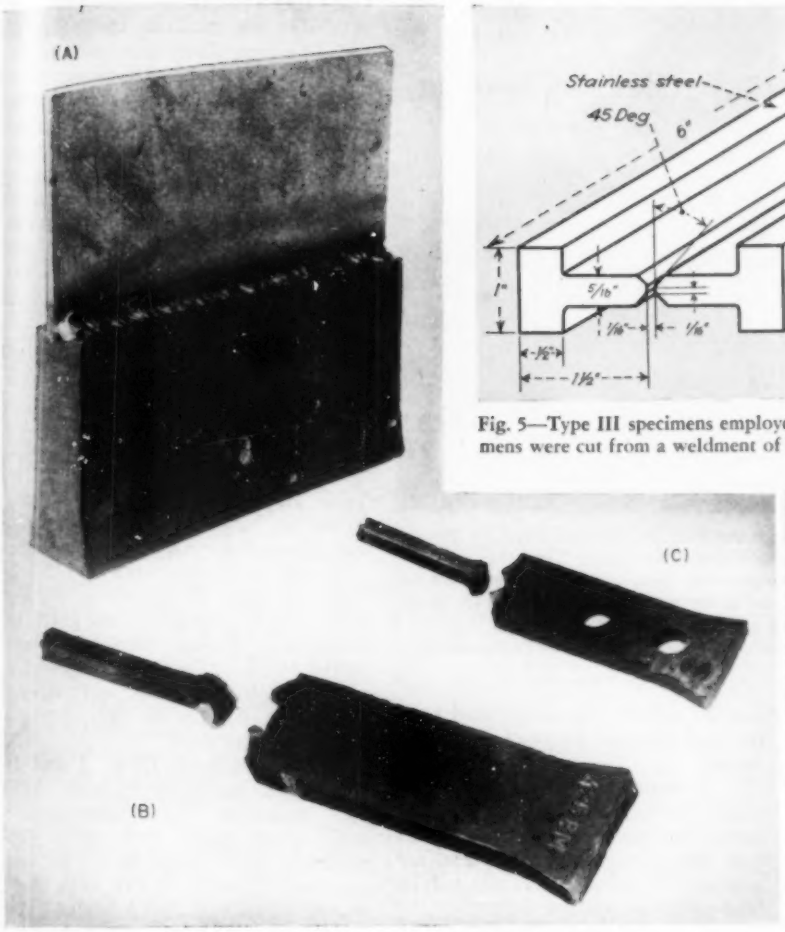


Fig. 4—(A) Test specimen for preliminary evaluation. With a fillet on one side only, the sheet was bent over weld. For tensile testing, sections were cut out of a similar weldment except that fillets were made on both sides of sheet. (B) Type I specimen after room temperature tensile test. (C) Type II specimen after tensile test at 750 F.

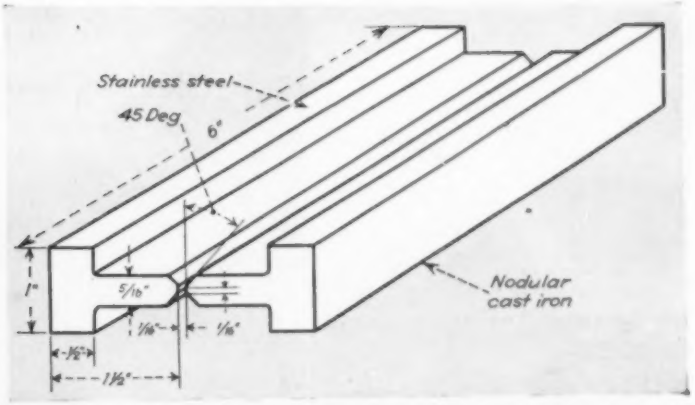


Fig. 5—Type III specimens employed to obtain welded standard tensile specimens were cut from a weldment of bars previously machined to shape shown.

Fig. 6—Type IV specimen consists of circular plates of nodular iron welded to the ends of a stainless steel tube. The specimen shown was welded with AISI 431 electrode, when tested at a temperature of 750 F it failed in the stainless sheet.

on $\frac{3}{32}$ in. sheet metal, while that of the specimen is a double fillet on a $\frac{3}{16}$ in. plate. The weld size and weld chemistry, however, are essentially the same. The cast iron base of the specimen is 3 in. thick and the thickness of the actual part varies from $\frac{3}{16}$ to 1 in. For this reason the degree of restraint in the specimen is more severe than in the actual part.

When the room temperature properties of Type I specimens appeared to be satisfactory on the basis of the stress developed in the stainless sheet at failure, Type II specimens were made and the elevated temperature properties checked. More costly and elaborate tests were reserved for those few procedures that could pass this rather thorough screening process.

TYPE III SPECIMENS. Welded standard $\frac{1}{4}$ in. tensile specimens were machined from specimens previously machined as shown in Fig. 5.

TYPE IV SPECIMENS. To evaluate a tensile specimen that more nearly duplicated the stresses encountered in service, the specimen shown in Fig. 6 was designed. In preparing this specimen, circular plates of nodular iron are welded to each end of a stainless steel tube $2\frac{1}{2}$ in. in diameter, $6\frac{1}{2}$ in. long and 0.094 in. wall thickness.

Evaluation of Welding Processes

The inert gas shielded metal arc process was first investigated using several compositions of welding wire. These compositions included inert gas welding grade nickel wire, commercially pure nickel, 60-40 nickel iron, aluminum bronze of 8 and 10 percent aluminum; and stainless steels, both austenitic and ferritic. Severe cracking occurred in all except the aluminum bronze welds. In welding the nodular cast iron and stainless steel specimens, argon was used as the shielding gas.

On the basis of the results of this preliminary evaluation, only welds made with aluminum-copper (bronze) wire appeared to be worthy of continued investigation. Further tests at room temperature and at 750 F, were made for several conditions of heat-treated aluminum bronze welds.

Microscopic examination of the bronze weld deposit showed globules of white iron in the aluminum copper

Fig. 7—Typical failures of joints welded with the inert gas shielded metal arc process using 92 percent copper 8 percent aluminum welding wire. (A) "As-welded" condition. Maximum stress in the sheet was 87,000 psi when joint failed. (B) Heat-treated at 1000 F and above. Failure consistently occurred at the weld-interface. Note crack in the globule of white iron that is trapped in the weld deposit. Maximum stress developed in the sheet was 66,700 psi when the welded joint failed at the weld-interface.

matrix. This condition occurs because iron and copper base alloys are not soluble in large proportions and would exist in all welds made with aluminum-copper.

From the results of these tests, it was concluded that:

1. Welds made with aluminum-copper by the inert gas shielded metal arc process have relatively good mechanical properties at room temperature and at 750 F in the "as welded" condition, and that any heat-treatment above 800 F results in a substantial decrease in strength. Fig. 7(A) shows the type failure in an "as welded" specimen. The effect of heat-treatment at 1000 F is indicated by the mode of failure shown in Fig. 7(B). Note also that the globules of white iron cracked under stress and would be a constant potential source of premature failure.

2. A large area of hard white iron under the weld is unavoidable when using aluminum copper welding wires with the inert gas shielded metal arc process and cannot be eliminated by heat-treatment without destroying the strength of the weld. The presence of such a large mass of hard brittle white iron is undesirable under any condition and could not possibly be tolerated in an area that is to be subjected to high stresses.

3. The necessity of operating the inert gas metal arc at relatively high energy levels prevented welding without getting excessive weld dilution from the low melting base metal.

Manual Metal Arc Welding Investigation

On the basis of work accomplished with the inert gas shielded metal arc process, it was possible to some extent to predict the requirements for a successful welding procedure. The welding wire should have good solubility with iron, a reasonable tolerance for carbon, and should preferably result in an austenitic deposit. To avoid overheating of the iron, the weld material should be capable of being deposited at a low current, too low in fact, for practical use of the inert gas metal arc process.

In investigating the manual metal arc welding process, specimens of the type shown in Fig. 4(A) were welded on one side only, using the following austenitic type of stainless steel electrodes, AISI 310, 312, 316, 330, 347. All specimens, when bent, broke through the weld and showed very little ductility. Before they were broken, most of the specimens had weld cracks. The results were so unsatisfactory that further testing appeared unnecessary with these electrodes.

Similar tests were made using the ferritic type of stainless steel electrodes AISI 430, 442, and 446; and the martensitic type of stainless steel AISI 431 electrode. The electrode referred to as AISI 431 was made by coating AISI 430 wire with a flux containing about 2.00 percent nickel. Of these, AISI 431 and 430 gave the best results, with the AISI 431 appearing to be superior. It was difficult to break the specimen by bending. When fracture did occur, large pieces of cast iron were pulled out by the weld. Further welding development was then concentrated on these welding electrodes.

MECHANICAL PROPERTIES OF WELDED SPECIMENS. The results of tensile tests on Type I specimens made using AISI 431 welding electrodes, after various heat-treatments, are given in Table I. Similar tests were made on Type I specimens using AISI 430 electrodes with results as given in Table II. It will be noted that the values are not as high as those obtained using an AISI 431 electrode.

Results of tensile tests at 750 F made on Type II specimens welded with AISI 431 electrodes are given in Table III. Failure consistently occurred in the stainless sheet. Welds made with this electrode were strong enough to develop the full strength of the stainless sheet.

A comparison of Tables I and II shows that welds made with AISI 431 electrodes were nonmagnetic, while those made with AISI 430 electrodes were magnetic. The one exception is the AISI 431 weld heat-treated at 1400 F for 3 hours. The nonmagnetic weld indicates that under normal conditions the 2 percent nickel in the AISI 431 welding wire was just enough to hold the deposit austenitic. The weld deposit should be austenitic so as to match the coefficient of expansion of the austenitic castings and struts. Because of the apparent superiority of AISI 431, evaluation of AISI 430 was discontinued.

Standard ½ in. dia tensile specimens were machined from Type III specimens welded with AISI 431 electrodes. The nodular cast iron portion of the specimens were machined from a standard Y-bar. The stainless steel portion was machined from AMS 5645 bar stock.

The welding procedure for making these specimens required special care. Single pass welds were made on each side of the joint with the bead size being large enough to fill the groove completely. Welds were started and stopped on sheet metal tabs. After the first pass, the root of the joint was carefully ground out to remove all flux. The work pieces were not restrained during welding, since the two pieces were out of alignment just enough after the first pass for

the weld shrinkage of the second pass to pull them straight.

The results of tensile tests made on these standard specimens are given in Table IV. Because these specimens included three kinds of material, it was difficult to interpret the elongation between gage marks. The weld deposit showed no reduction after failure, since the yield strength of the weld apparently had not been reached. The stainless steel just started to yield at failure, while the cast iron portion of the specimen was greatly reduced with almost all of the yielding taking place in that section. The appearance of this portion was the same as on specimens made entirely of nodular cast iron. Tensile strengths compare favorably with those found for nodular cast iron, which is about 60,000 psi at room temperature and about 50,000 psi at 800 F.

Test results on Type IV tensile specimens made using AISI 431 electrodes and tested at 750 F are given in Table V. In all these, failure occurred in the stainless sheet. Fig. 6 shows how the stainless tube yielded.

All the tensile tests made on specimens welded with AISI 431 electrodes show that the short time tensile properties of the welded joint are as good, or better, than the base metal materials.

Microscopic examinations of composite welds made with AISI 431 electrodes show that the formation of white cast iron under the deposit could not be entirely prevented. After treatment at 1400 F for 3 hours, some breakdown of the white iron is obtained, with the carbon appearing as flake graphite rather than nodules. The hardness of the white iron was found to drop from R_c51 to R_c44, while the weld deposit increased from R_b 97-100 to R_c 22-23. The change from a nonmagnetic weld deposit to a magnetic one further indicates a transformation from the austenitic state at this elevated temperature.

Since the results of the tensile tests, Table I, showed that no improvement in properties is obtained by treatment at temperatures from 900 to 1400 F, any treatment in addition to the stress relief was deemed to be inadvisable.

Because of dilution the weld deposit is largely austenitic, and as a result is compatible with the two base materials. A chemical analysis of the deposit gave the following results:

	Percent
Carbon	0.50
Manganese	0.92
Nickel	5.15
Chromium	13.3
Silicon	0.88

Table I—Tensile Test Results of AISI 431 Welds With Type I Specimens

Welding Process	Manual metallic arc
Welding Wire	AISI 431, 1/8 in. dia
Shielding	Flux coated electrode
Welding Current	90 amp—reverse polarity

Tests were made at room temperature

Specimen	Heat-Treatment	Stress in Sheet at Failure, psi	Type of Failure	Properties of Weld Deposit
1	As welded	91,000	Pulled out of the iron	Nonmagnetic
2	As welded	96,500	Stainless sheet	Nonmagnetic
3	900 F—1 hr	93,500	Pulled out of the iron	Nonmagnetic
4	900 F—1 hr	96,700	Stainless sheet	Nonmagnetic
5	1000 F—1 hr	63,000*	Underbead crack	Nonmagnetic
6	1000 F—1 hr	93,000	Stainless sheet	Nonmagnetic
7	1100 F—1 hr	90,000	Shear through weld	Nonmagnetic
8	1100 F—1 hr	88,500	Shear through weld	Nonmagnetic
9	1400 F—3 hr	84,000	Shear through weld	Magnetic
10	1400 F—3 hr	90,000	Shear through weld	Magnetic

* This lower value was the result of an underbead crack. There has been no indication of this kind of difficulty on the welded composite unit where the restraint is far less than in Type I specimens.

Table II—Tensile Tests Results of AISI 430 Welds With Type I Specimens

Welding Process	Manual metallic arc
Welding Wire	AISI 430, 1/8 in. dia
Shielding	Flux coated electrode
Welding Current	90 amp—reverse polarity

Tests were made at room temperature

Specimen	Heat-Treatment	Stress in Sheet at Failure, psi	Type of Failure	Properties of Weld
1	As-welded	85,000	Pulled out of the iron	Magnetic
2	As-welded	81,400	Shear through weld	Magnetic
3	As-welded	68,000	Underbead crack	Magnetic
4	800 F—1 hr	82,000	Pulled out of the iron	Magnetic
5	800 F—1 hr	77,000	Pulled out of the iron	Magnetic
6	1100 F—1 hr	90,000	Pulled out of the iron	Magnetic
7	1100 F—1 hr	66,800	Underbead crack	Magnetic
8	1400 F—1 hr	85,000	Shear through weld	Magnetic
9	1400 F—1 hr	88,200	Pulled out of the iron	Magnetic

Table III—Tensile Test Results of AISI 431 Welds With Type II Specimens

Welding Process	Manual metallic arc
Welding Wire	AISI 431, 1/8 in. dia
Shielding	Flux coated electrode
Welding Current	90 amp—reverse polarity

Tests were made at a temperature of 750 F

Specimen	Heat-Treatment	Stress in Sheet at Failure, psi	Type of Failure
1	As-welded	65,500	Stainless sheet
2	As-welded	65,700	Stainless sheet
3	As-welded	65,700	Stainless sheet

Table IV—Tests on Standard ¼ in. Tensile Specimens Machined from Type III Specimens

Welding Process	Manual metallic arc
Welding Wire	AISI 431, 1/8 in. dia
Shielding	Flux coated electrode
Welding Current	90 amp—reverse polarity

Specimen	Temperature	Stress at Rupture, psi	Type of Failure
1	Room	60,500	Iron-weld interface
2	Room	62,500	Iron-weld interface
3	800 F	52,500	Cast iron
4	800 F	53,500	Cast iron

Table V—Tensile Tests of AISI 431 Welds With Type IV Specimens

Welding Process	Manual metallic arc
Welding Wire	AISI 431, 1/8 in. dia
Shielding	Flux coated electrodes
Welding Current	90 amp—reverse polarity

Tests were made at a temperature of 750 F

Specimen	Stress in Sheet at Failure, psi	Type of Failure	Comments
1	58,000	Sheet	Failure started where thermocouple wire was brazed to sheet metal
2	68,000	Sheet	Necked down considerably before failure

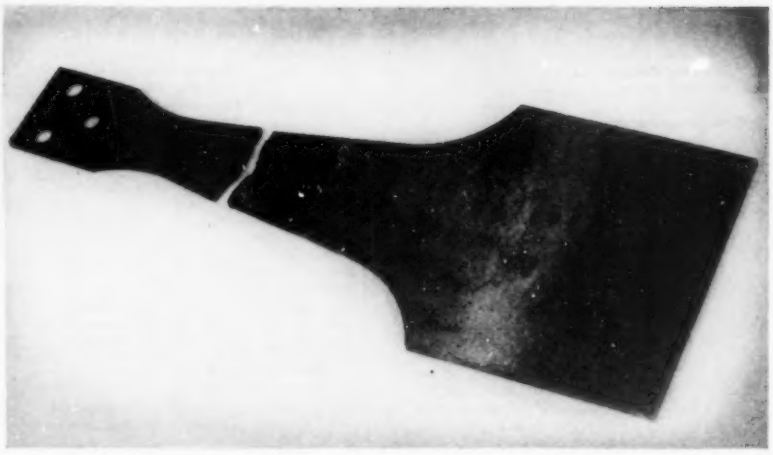


Fig. 8—Constant stress beam specimen tested on a Krouse plate bending fatigue machine. Failure occurred in the iron at a considerable distance away from the weld.

Table VI—Fatigue Test of Composite Weld Material

Specimen	Heat Treatment	Stress, psi	Cycles	Location of Failure
1	As-welded	25,000	604,000	Weld-iron interface
2	850 F—4 hr	25,000	10,090,000	No failure
3	850 F—4 hr	25,000	10,000,000	No failure
4	850 F—4 hr	25,000	10,000,000	No failure

From the results of the tests on specimens made with AISI 431 welds, it was concluded that:

1. Electrode AISI 431 shows excellent compatibility with the base materials investigated.

2. The resulting weld deposit has a good tolerance for carbon, a relatively stable austenitic structure, shows no evidence of being crack sensitive and produces a relatively small amount of white iron in the Ni-Resist.

3. The mechanical properties of AISI 431 welds as determined by composite specimens sufficiently fulfill the requirements for the part.

Development of Stress Relief Treatment

Base metal evaluation and development were carried on concurrently with the investigation of welding techniques. It was found that the first analysis, austenitic nodular cast iron containing about 20 percent nickel, was so unstable that thin sections of the castings had sizeable amounts of martensite at room temperature in the as-cast condition.

Castings that had been stress relieved at 1100 F had even greater amounts of martensite, indicating that high temperature heat-treatments "conditioned" the austenite and made it more unstable. To correct this instability, since the military requirements for this part call for a material that remains stable at —75 F, the alloy content of the castings was modified somewhat by increasing the manganese content.

The present analysis, containing 21 to 26 percent nickel, is stable but since high temperature heat-treatment affects stability adversely, it is considered desirable to keep stress relief treatments at temperatures below 1000 F. This sensitivity of the base metal to instability after high temperature heat-treatment was paralleled by the behavior of the weld deposit. As recorded in Table I, heat-treatments of 1400 F changed the weld from nonmagnetic to magnetic, indicating that the austenite was transformed. This behavior of the weld and base metal showed the necessity for keeping the stress relief temperatures as low as practical.

Relaxation data on the base metal show that a treatment of 850 F for 4 hours will remove from 30 to 35 percent of the locked-up stresses. Although complete stress relief is not obtained, it is an optimum compromise.

Evaluation of Fatigue Problem

The fatigue strength of the composite welded material was determined by using a Krouse plate bending fatigue machine, results of this test are given in Table VI. Constant stress beams were machined from specimens of $\frac{1}{4}$ in. stainless sheet welded to $\frac{1}{4}$ in. thick nodular cast iron, using AISI 431 flux coated welding electrodes. They were surface ground on both sides to a thickness of 0.125 and machined into specimens. One of these specimens is shown in Fig. 8. The larger end is stainless sheet and the smaller end is nodular cast iron. The weld may be seen at about the middle of the tapered portion.

The short life of specimen 1, Table VI, may have resulted from lack of stress-relief. Specimens that were stress relieved ran 10,000,000 cycles without failure. To ascertain the location of failure, the stress was increased to a high level. No attempt was made to determine the magnitude of this stress. Failure occurred in the cast iron, thus indicating that on stress relieved parts the limiting factor in fatigue strength would be the strength of the nodular iron, not the metallurgical properties of the weld deposit or of the heat affected zone on either side of the deposit.

Conclusions

The foundry and welding problems, associated with the use of ferritic nodular iron for the center main bearing support and similar parts, are still being investigated to conserve alloys.

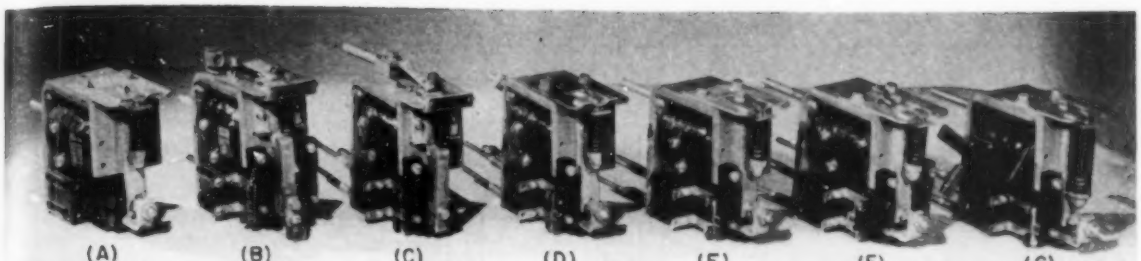
Up to the present, however, producibility studies have resulted in the development of improved materials, precision foundry techniques, and processes that produce welds of excellent quality.

As a result of these studies, a composite welded center main bearing support for the Wright-Sapphire turbojet engine is being produced that has several outstanding production and design advantages:

1. It is highly producible. Time consuming contour milling has been replaced by simple turning and welding operations that require no unusual tooling.

2. It is made of an iron base alloy that at 750 F is about six times as strong as the original aluminum alloy.

3. It is comparable in weight; it is only 15 percent heavier than the original aluminum part.


(A) Plugging relay
(B) Double winding coil Timetactor
(C) Single winding coil Timetactor
(D) Time delay relay
(E) Anti-plugging relay
(F) Control relay
(G) Overload and jamming relay

Direct-Current Relays and Devices for Industrial Motor Controllers

Magnetically operated components of direct-current motor controllers for performing timing and protective functions. Principles of operation, construction, pickup and dropout characteristics of seven relays and devices of similar and coordinated design. Charts of typical controller application diagrams in which these devices control operation of motors.

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IN THE DESIGN of motor controllers associated with production processes, the trend is toward replacing manual operations with automatically controlled operations. Automatic control not only results in lower product cost by maintaining efficient production cycles, but also removes the hazards of an operator not functioning properly. It contributes toward the safety and convenience of the operator, and protects the motors, driven equipment, and often the quality of the manufactured product.

To achieve these objectives, modern d-c industrial motor controllers require numerous electrical devices and relays to perform the necessary switching, detecting, sensing, timing and protective functions. The designer of such controllers is faced with the often difficult problem of properly selecting or specifying the component parts such as d-c magnetically operated plugging relays, time limit accelerating relays, time delay relays, anti-plugging relays, control relays, and overload and jamming relays.

The numerous variety of relays and devices required and the relatively small number of specific devices needed often present a rather difficult problem to the builder of medium and large size controllers.

The group of relays and devices shown above are all employed as component units of industrial motor controllers. These devices appear to be practically alike but, despite the similarity in appearance, the application and function of the individual devices are different. Their similarity in appearance and uniformity in size contribute toward the good appearance of a complete d-c motor controller. The similarity in construction also facilitates servicing and maintenance with a small inventory of spare parts.

The principal difference between these seven different types of relays and devices is in the magnetic circuit, operating coils, and mode of operation. In Fig. 2 their magnetic circuit characteristics are compared.

Primarily, the dropout characteristics of these devices are controlled by the thickness of the nonmagnetic shim or spacer assembled in the armature end of the core. In controlling the

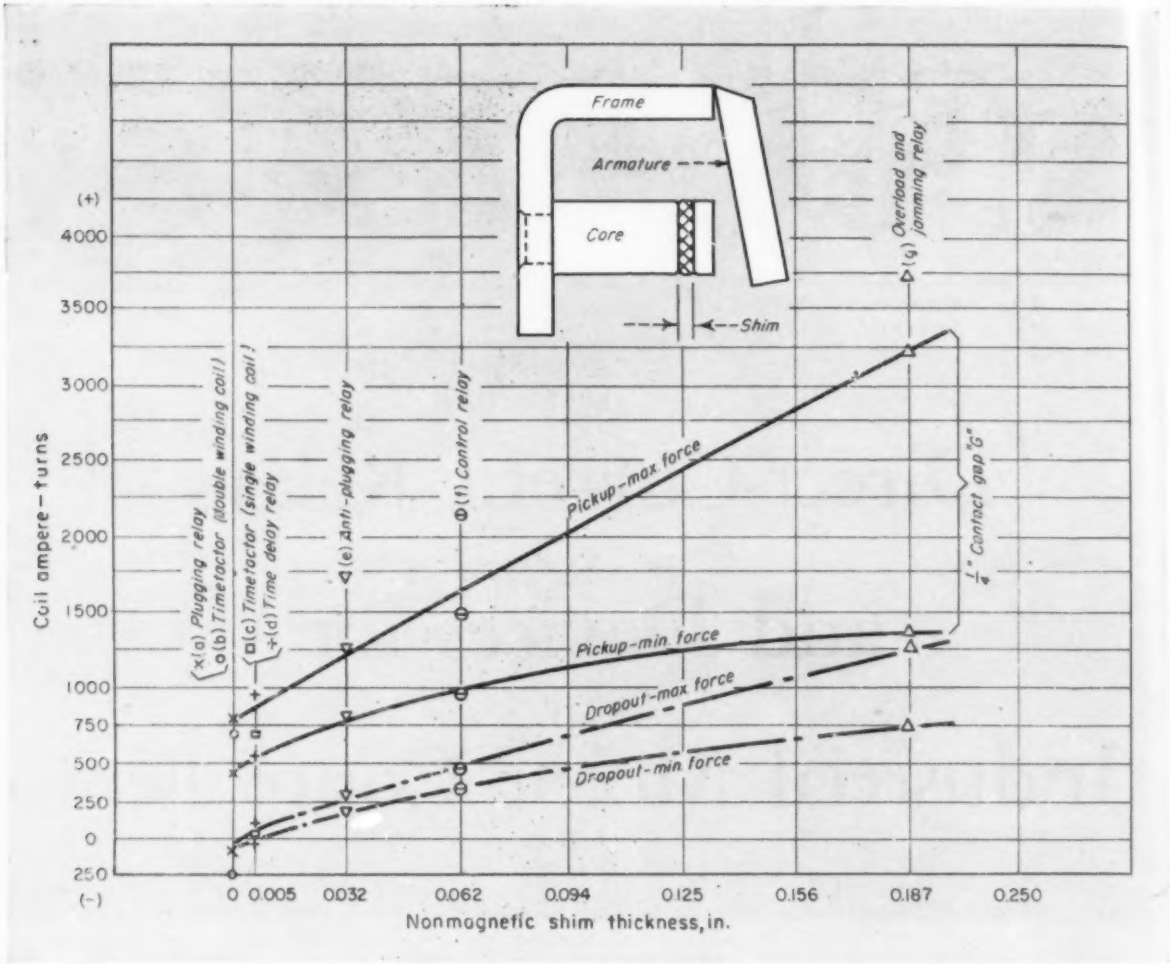


Fig. 2—Armature pickup and dropout characteristics of seven different types of relays and devices employed in motor controllers.

flux in the magnetic circuit, this shim is analogous to a control orifice.

The pickup value is controlled mainly by the air gap between the end of the core and the armature.

Both the dropout and pickup values are affected by the force of the armature kickout spring.

The relays and Timetactors shown in Fig. 1(A) through (E) operate principally on the dropout characteristic. Both the dropout and pickup magnetic characteristics for this group are in a low ampere-turn range.

Control relay, Fig. 1(F), is for general application and does not require either a critical pickup or drop-out characteristic.

The magnetically operated overload and jamming relay, Fig. 1(G), utilizes both the pickup and dropout characteristics. For strictly overload applications, only the pickup value is of importance. For jamming protection, a certain ratio of pickup to dropout is required and both the pickup and dropout features are utilized.

Plugging Relay

A d-c motor is plugged by reversing the polarity of the voltage applied to the motor armature while it is running at full speed. By employing power from the line to decelerate and stop the motor, plugging reverses the direction of motor rotation in a minimum of time. During the plugging operation, all steps of the starting resistor and an additional resistor step known as the plugging resistor are inserted into the motor armature circuit. This resistance limits the motor current to a safe value.

Two plugging relays are required in the Westinghouse plugging control scheme. They are so connected that when a motor is started from standstill, the plugging step of the resistor is shorted out immediately; and when a motor in motion is plug reversed, the plugging resistor is instantly inserted into the armature circuit. The plugging relays prevent the reclosing of the plugging contactor until the motor armature decelerates almost to standstill. The inherent counter emf characteristic of the motor is utilized to provide a signal, which has both rate of speed and directional characteristics, for the plugging relays.

The particular type of plugging relay shown in Fig. 1(A) is a d-c magnetically operated device for controlling the closing of the plugging contactor of a d-c reversing and plugging motor controller.

The armature and frame assembly constitute the magnetic circuit of this relay. Since the relay operates upon a residual magnetism principle, the reluctance of the magnetic circuit is kept as low as possible by not using a nonmagnetic shim or air gap in the magnetic circuit.

This relay has a two-winding coil: a main winding for closing and a neutralizing winding for controlling the release or dropout of the relay armature. The wire in the neutralizing winding has a low temperature

coefficient of resistance; therefore, normal ambient and operating temperatures have only a slight effect on the performance of the relay.

When the main winding is energized with a d-c voltage that is within the operating limits, the armature closes against the iron core pole-face and opens the main control contact. As the coil current increases to its steady state value, the flux in the magnetic circuit increases to its maximum value. Next, when the main winding is de-energized, the flux in the iron circuit immediately decays to the residual value. The armature remains in its closed position, however, since the magnetic force produced by the residual flux exceeds the force of the armature kickout spring.

To release the armature, a magnetizing force in opposition to that of the main coil must be imposed on the magnetic circuit to reduce or neutralize the residual magnetism. This opposing magnetizing force is produced by energizing the neutralizing winding. As this de-magnetizing force increases, the residual flux value decreases. When the flux in the magnetic circuit is reduced to the dropout or armature release value, the armature is released to close its main control contact. Armature dropout time depends only upon the time it takes for the neutralizing winding magnetic force to reach the armature release value.

Since its operation is based upon an electro-magnetic phenomenon, this plugging relay has a consistent dropout characteristic.

The armature pickup value can be varied by adjusting both the armature kickout spring force and the armature gap; means for making these adjustments are shown in Fig. 3(A). The dropout voltage or ampere-turn value can be adjusted only by changing the armature kickout spring force.

To control the closing of the plugging contactor (dropout of the plugging relay) at a specific motor speed, a potentiometer, Fig. 3(B), is generally used in conjunction with the neutralizing winding. The voltage tapped off the potentiometer adds to the motor armature IR voltage drop; thus the plugging resistor can be shorted out even before the motor armature decelerates to zero speed. This feature also helps to reduce the time required for reversing from full speed in one direction to full speed in the opposite direction.

Timetactors

One small and two large frame Timetactors are shown in Fig. 4. These d-c magnetically operated devices combine in one unit the functions of a definite time limit accelerating relay and a spring or normally closed magnetic contactor.

The small frame size assembly, Fig. 4(A), provides a range of $\frac{3}{4}$ to 3 seconds time delay. This assembly is supplied with studs for rear connection or with pressure terminals for front connection, depending upon the controller wiring requirements.

The large frame size assemblies, Fig. 4(B) and (C), give time delay periods in a range of 1 to 5 seconds. The large frame double pole assembly is rated lower than the corresponding single pole unit because the current rating is limited by the current capacity of the common moving contact assembly for two stationary contacts.

Single pole types are primarily used for d-c general purpose and marine definite time limit starters. Double pole types are used mainly for accelerating contactors in the secondary circuit of a-c wound rotor induction motor controllers.

The main contacts of these devices are for circuit closing service only and are always applied so that they are never required to interrupt any current. (See "Some Design Considerations for Electrical Contact Operation," PRODUCT ENGINEERING, February 1947, p 107.)

In both types of assembly, the main stationary contacts serve as the armature stop. The main moving contact is both electrically and mechanically connected to the armature and frame. A flexible shunt conducts the current from the moving contact to the stud or terminal and reduces the current flowing through the frame parts to a very small value. This shunt is connected to the moving contact at a point close to the bearing line of the armature so that little mechanical motion is imposed on the shunt. Another advantage to the current carrying parts being mounted on the armature and frame surfaces is that these iron parts provide additional heat conducting and radiating surfaces.

Both small and large frame size Timetactors are manufactured with a double winding coil. Another type of small frame size assembly with a shim in the core face, however, is manufactured with a single winding coil.

DOUBLE WINDING COIL TYPE. Since these devices operate upon an inductive time delay principle that requires the reluctance of the magnetic circuit to be as low as possible, there are no substantial air gaps or nonmagnetic

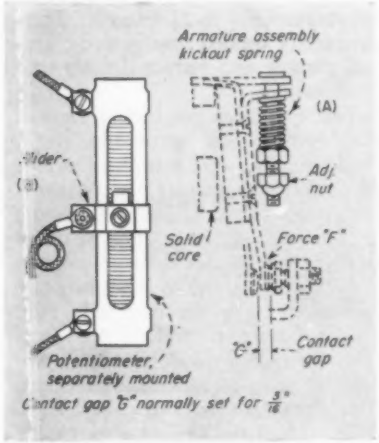


Fig. 3—(A) Assembly for varying the force of the armature kickout spring in a plugging relay. (B) Potentiometer.

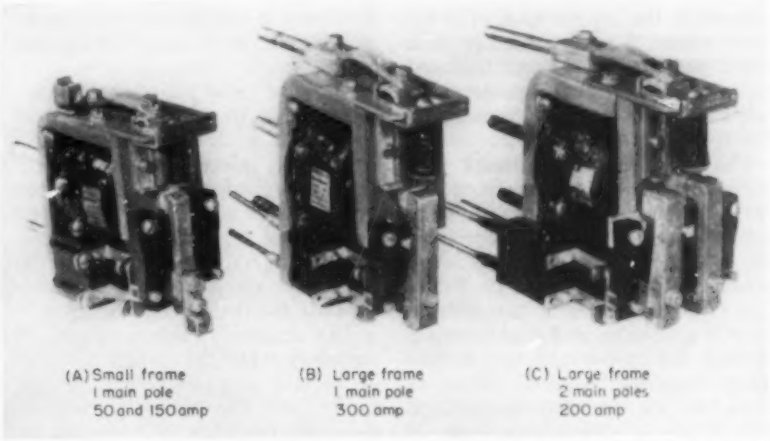


Fig. 4—Direct current magnetically operated devices that combine in one unit the functions of a definite time limit accelerating relay and a normally closed magnetic contactor. The main contacts of these devices are for circuit closing service only.

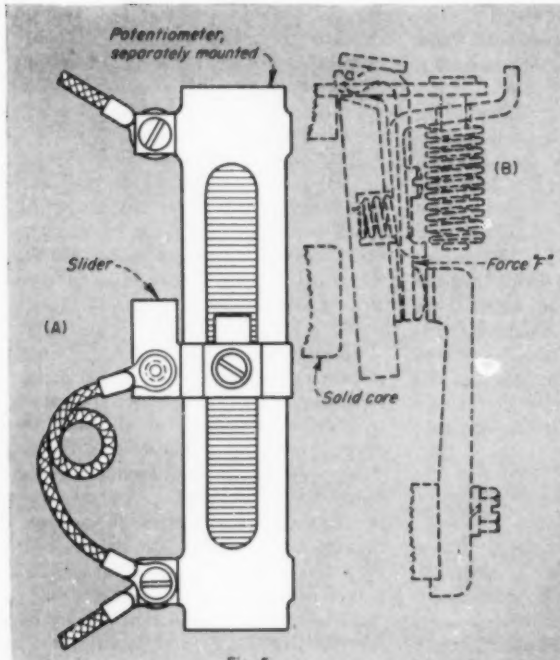


Fig. 5

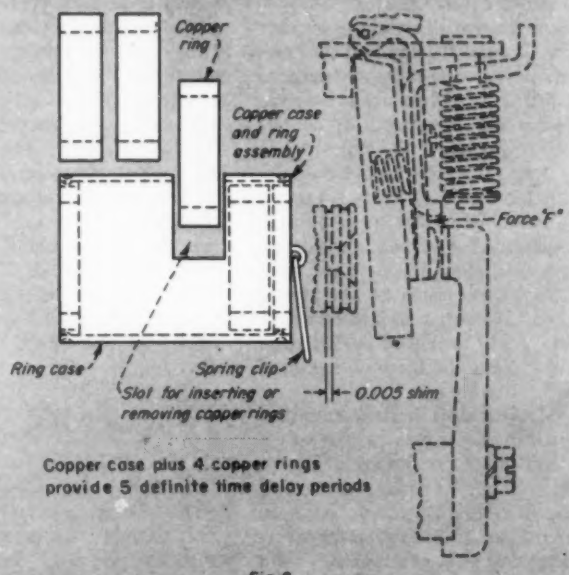

Copper ring
Copper case and ring assembly
Force "F"
Ring case
Spring clip
Slot for inserting or removing copper rings
0.005 shim
Copper case plus 4 copper rings provide 5 definite time delay periods

Fig. 6

Fig. 5—(A) Potentiometer for varying the ampere-turns of the neutralizing winding of a double winding coil type Timetactor. (B) To prevent decreasing the contact force, the support for armature kickout spring is designed to be non-adjustable. Main contact gap is non-adjustable.

Fig. 6—Copper case and ring assembly in a single winding coil type Timetactor. The slotted tubular copper case fits over the core piece.

Fig. 7—Time delay relays. Small frames: (A) one auxiliary contact; (B) Four auxiliary contacts. (C) Large frame, one auxiliary contact.

Fig. 8—Time delay relay with spring stud clevis partially disengaged from bearing plate. Flexible shunt connects moving contact with frame.

spacers in the magnetic flux circuits.

The inner winding of the double winding coil is the main or pickup winding; the outer winding is the neutralizing winding. This double winding coil is assembled on a heavy copper tube, which fits over the iron core. The copper tube serves as a short-circuited low resistance winding.

When the main winding is energized with a d-c voltage that is within the operating limits, the armature closes against the iron core and opens the main contact. The time delay period is then initiated by opening the main coil circuit to de-energize that winding. When the magnetic field of the main coil collapses, a current is induced in the copper tube. The induced current flows in a direction such that it sustains the magnetic field and prevents the magnetizing force imposed on the iron circuit from immediately dropping to zero.

The armature is not released even when the magnetizing force produced by the copper tube decays to zero, since the magnetic holding force produced by the residual flux exceeds the armature kickout spring force. To release the armature, a magnetizing force in opposition to that of the main winding and copper tube must be imposed upon the magnetic circuit to neutralize the residual magnetism. This opposing magnetizing force is produced by energizing the neutralizing winding. As this demagnetizing force is increased, the flux in the iron circuit decreases. When the flux decreases to a value where the magnetic force is less than the force of the armature kickout spring, the armature is released to end the time delay period and to close the main accelerating contacts.

The time delay period, or duration of time from the instant that the main coil circuit is de-energized until the armature is released, can be continuously controlled over the entire range by varying the neutralizing coil current by means of a potentiometer or rheostat, Fig. 5(A). After the time delay period has elapsed, no reset time is required for the next timing cycle.

The armature kickout springs are purposely supported in such a way as to prevent any adjustment of the spring force, Fig. 5(B). A change in the spring force has little effect on the time delay period. Also, it is not desirable to decrease the main contact pressure.

SINGLE WINDING COIL TYPE. This type is manufactured only in a small frame size, which provides five individual time periods in a range from approximately ½ to 2¼ seconds. These devices are applied mainly to d-c general purpose and marine definite time limit starters.

This type does not have a neutralizing winding; it is operated by a single winding coil assembled over a copper or brass tubular case, which is slotted to receive and hold a maximum of four copper rings, Fig. 6. The tubular case fits over the core piece.

A nonmagnetic shim is permanently assembled under the core pole face. This construction protects the shim from being tampered with and prevents it from decreasing in thickness after repeated operations.

The armature kickout springs are supported as shown in Fig. 5(B) and are not adjustable.

When the coil is energized with a

d-c voltage, the armature seals against the core pole-face. The time delay period is then initiated by either opening or shorting the coil circuit. When the magnetic field of the coil collapses, a current is induced into the ring case and the copper rings surrounding the iron core inside the coil. This induced current flows in a direction such that it sustains the magnetic field and holds the armature closed even after the coil has been de-energized. When the decaying magnetic field force becomes less than the force of the armature kickout spring, the armature is released to end the time delay period.

When a Timetactor is operated by short-circuiting the coil, the time delay period is longer than that which results when opening the coil circuit, since the coil winding itself functions as an additional short-circuited winding. When the coil is short-circuited, it must be connected in series with a motor armature or a resistor to avoid short-circuiting the power supply.

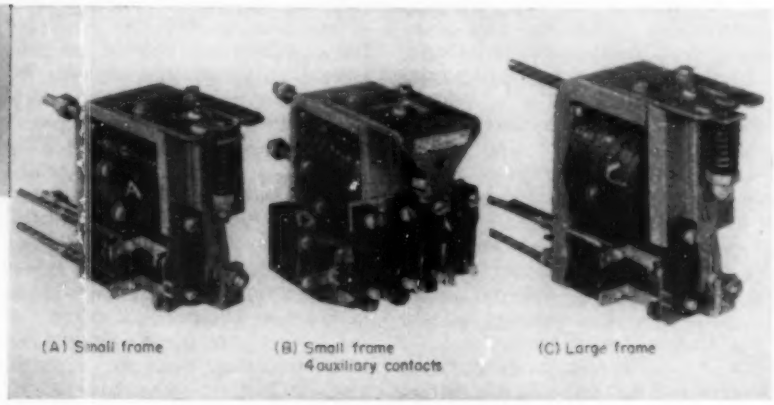
One of five time delay periods can be selected by changing the number of rings in the ring case. The period is a minimum when the ring case does not contain any rings; it is a maximum when the case contains four rings.

A brass ring case can be used to obtain time periods approximately ½ second shorter than those obtained with the normally used copper case. The higher resistance of brass results in less induced current, and consequently a shorter delay period.

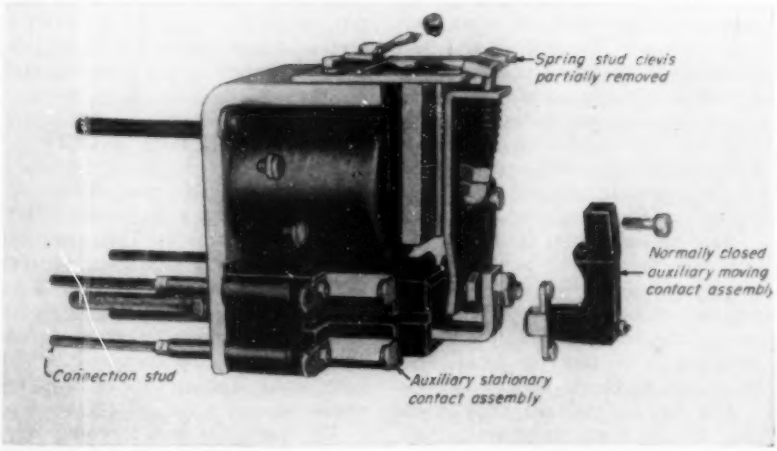
The shim in the magnetic circuit provides a uniform dropout characteristic and prevents the armature from being held closed by residual magnetism. In this particular circuit, the minimum armature kickout spring force is approximately twice the maximum magnetic force produced by the residual magnetism.

Compared with that of the device operated by a double winding coil, the maximum time delay period of the single winding device is considerably shorter. Also, the adjustment is entirely mechanical and the delay period is not continuously variable between the five steps. The time delay period of the double winding device is continuously adjustable over its entire range, and can be remotely adjusted with a separately mounted potentiometer or rheostat.

Since the single winding device does not require an adjusting resistor, the wiring is considerably reduced. The simplicity of the wiring often compensates for the shorter time period and reduced adjustability. Where the time setting is not too critical, the single winding device is adequate for most general purpose starters. Its simplicity and ruggedness make it particularly suitable for mining service.



(A) Small frame (B) Small frame 4 auxiliary contacts (C) Large frame


Spring stud clevis partially removed
Normally closed auxiliary moving contact assembly
Connection stud
Auxiliary stationary contact assembly

Time Delay Relays

Inductive time delay d-c magnetically operated relays are specifically designed for controlling the accelerating contactors of definite time limit acceleration controllers. The reliability and ruggedness of these relays make them particularly well suited for application to d-c steel mill control.

Small and large frame time delay relays are shown in Fig. 7. The small frame assembly provides a delay period ranging from approximately ⅔ to 2 seconds. The large frame assembly gives a time period ranging from 1 to 3½ seconds. They are similar in appearance and use many common parts. The main difference is in the size of the frame and operating coil. The iron section in the large frame is approximately 60 percent larger than that in the small frame assembly.

The small frame assembly shown in Fig. 7(A) has one main contact and one normally open auxiliary contact. A total of any combination of two normally open or closed auxiliary contacts can be applied to this relay assembly. The small frame relay, Fig. 7(B), can be assembled with various combinations of normally open or closed auxiliary contacts up to a maximum number of four.

These relays operate upon an inductive time delay principle. They are operated by a single winding coil. They have a ring case and copper ring assembly installed in the operating coil to serve as a short-circuited low resistance winding. They have a nonmagnetic shim permanently assembled under the core pole-face.

When the coil is energized with a d-c voltage, the armature seals against the core pole-face. The time delay period can then be initiated by either opening or shorting the coil circuit. When the magnetic field of the coil collapses, the current induced into the ring case and copper rings flows in a direction such that it sustains the magnetic field and holds the armature closed after the coil has been de-energized. When the decaying magnetic field force becomes less than the force of the armature kickout spring, the armature is released and opens to end the time delay period.

The shim reduces the residual flux

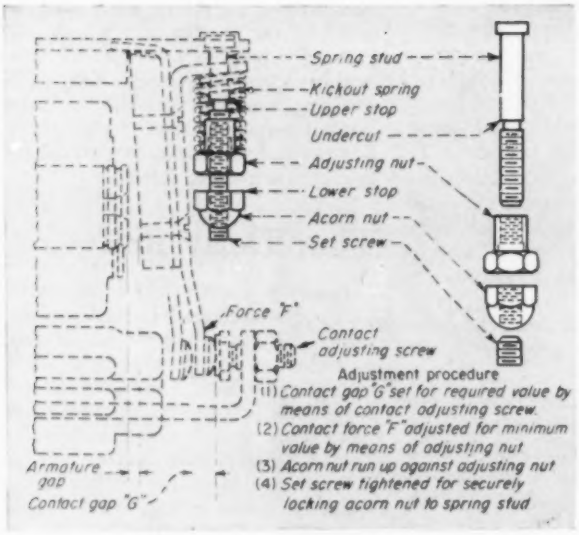

Spring stud
Kickout spring
Upper stop
Undercut
Adjusting nut
Lower stop
Acorn nut
Set screw
Force "F"
Contact adjusting screw
Adjustment procedure
(1) Contact gap "G" set for required value by means of contact adjusting screw.
(2) Contact force "F" adjusted for minimum value by means of adjusting nut
(3) Acorn nut run up against adjusting nut
(4) Set screw tightened for securely locking acorn nut to spring stud
Armature gap
Contact gap "G"

Fig. 9—Relay kickout spring adjusting nut, spring stud, and stop assembly for limiting the spring force to safe values.

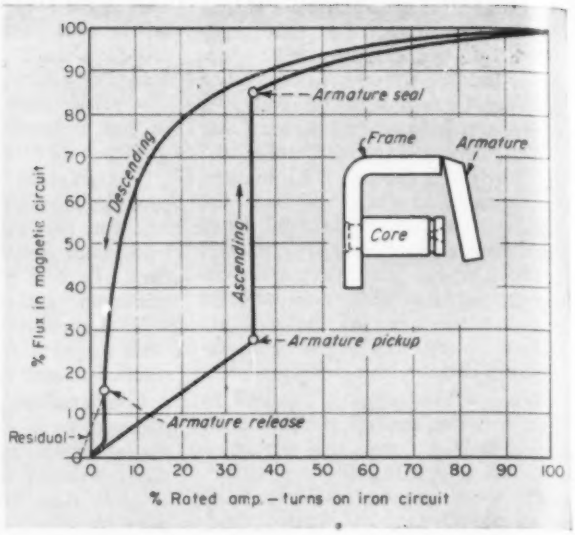


Fig. 10—Time delay relay hysteresis curve for ampere-turns and flux in iron circuit achieved with a large iron section.

such that its magnetic force is approximately one-half of the minimum kickout spring force. This ratio insures the release of the armature under any operating condition.

The time delay period can be continuously adjusted both by changing the number of rings in the ring case and by varying the kickout spring force. The spring acts as a vernier to graduate the intervals between the steps in the time delay periods obtainable with the copper rings.

To limit the spring force to safe maximum and minimum values, the construction shown in Fig. 9 is used on all relays in this group that have adjustable armature kickout spring assemblies. To insure positive armature release, the position of the lower stop on the spring stud is adjusted during assembly and then locked by the set screw. The upper stop prevents compressing the spring to a degree such that the relay will not pick up on normal operating voltages.

The arrangement of the spring stud clevis and the knife-edge bearing plate shown in Fig. 8 makes it possible to remove quickly the entire armature assembly for time adjustment or maintenance. When normally closed auxiliary contacts are assembled on the relay, the entire auxiliary moving contact assembly can be readily removed by taking out only one mounting screw.

For simplicity, the circuit for the main moving contact is from the rear frame mounting stud through the knife-edge bearing to the moving contact support. Despite exceptionally good field operational experience, a few users of this relay prefer an additional electrical connection between the moving contact and the frame. A flexible shunt assembly for this purpose is shown in Fig. 8 at the top of the relay.

One desirable design feature, which is obvious from Fig. 10, is that the pickup of the relay is reduced to as low as 35 percent of the rated voltage, by employing a relatively large iron cross-section. When the relay armature closes, the flux increases considerably for the same magnetizing force from the pickup to the sealed value as shown on the hysteresis curve. From this curve it should be noted that if the coil voltage is sufficient to close the armature, the iron in the magnetic circuit is always saturated.

When the ratio of increment of flux to increment of ampere-turns begins to decrease rapidly, the iron in the magnetic circuit is carrying all the flux that it can efficiently, and the iron is considered to be magnetically saturated. The magnetic characteristics of iron after it saturates are not much better than those of a nonmagnetic material. The iron in this particular magnetic circuit is saturated at approximately 20 percent of the rated operating coil ampere-turns. This feature helps to provide a time delay period that is practically independent of the operating voltage.

The residual flux for the small frame time delay relay is about 7,000 lines, approximately 7 percent of the maximum value. Without the nonmagnetic shim and with a solid iron circuit, the residual flux would normally be on the order of 50 kilolines or 50 percent of the maximum value.

Test data for the time delay period over an operating range from minimum pickup to 200 percent of the rated operating coil ampere-turns are plotted in Fig. 11. For all practical purposes, the time delay period can be considered constant for any value of voltage applied to the coil.

When permanently assembling the nonmagnetic shim behind the core pole-face by a hot riveting operation, a projection on the core is forged into a countersunk hole in the pole-face. Even though this assembly has a solid iron circuit from the core to the armature through the core projection, it is of no consequence. The cross-section area of the core projection is sufficiently small to saturate at a relatively low value of flux compared with the total flux in the magnetic circuit. The division of flux in the iron core projection and shim is shown in Fig. 12. The principal purpose of the shim is to reduce the residual flux to a low value. Since the minimum armature kickout spring force always exceeds by several times the residual flux magnetic force, the relay armature is always released a short time after de-energizing the operating coil.

Anti-Plugging Relay

Anti-plugging d-c magnetically operated relays have a relatively low dropout characteristic. Their main application is with d-c reversing controllers to prevent plugging of a d-c motor. Without a series plugging resistor in the motor armature circuit, the motor may be damaged by the commutator flashing over or by an excessive torque.

The particular anti-plugging relay

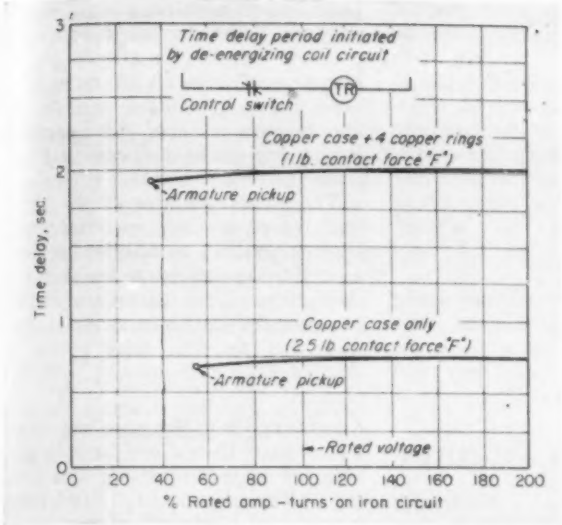

Time delay period initiated by de-energizing coil circuit
Control switch
TR
Copper case + 4 copper rings (11b. contact force "F")
Armature pickup
Copper case only (2.5 lb contact force "F")
Armature pickup
Rated voltage
Time delay, sec.
% Rated amp - turns on iron circuit

Fig. 11—Test data giving the time delay periods at different percentages of rated coil ampere-turns for a time delay relay.

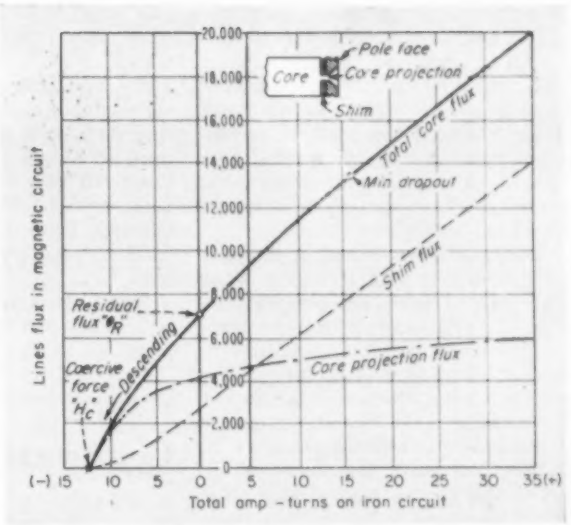


Fig. 12—Division of flux in iron core projection and shim in a time delay relay. Shim reduces the residual flux to a low value.

shown in Fig. 1(E) is operated by a conventional single winding voltage coil. A 0.032 in. thick nonmagnetic shim is assembled between the core and pole-face so that the relay has a fairly low dropout value.

The operation of these relays is similar to other conventional d-c magnetically operated control relays. The pickup voltage can be varied in a range of approximately 25 to 70 percent of the rated operating voltage by adjusting both the armature kickout spring force and the armature gap.

The dropout voltage can be varied in a range of 10 to 15 percent of the rated voltage by changing only the armature kickout spring force. For a given spring setting, the dropout voltage is the same regardless of the size of the main contact gap.

This type of relay is not recommended for general control relay applications because its low voltage dropout characteristic increases its dropout time. For anti-plugging applications, this slightly longer dropout time is of no importance as a short time interval is required to dynamically brake the motor down to a standstill.

Control Relay

The d-c magnetically operated control relay, Fig. 1(F) has an ordinary single winding coil. Relays of this type are suitable for application to general purpose d-c industrial and marine controllers.

A 0.062 in. thick nonmagnetic shim is assembled between the core and the pole-face so that the relay will have a fairly fast dropout.

When the operating coil is energized, the relay picks up and the armature remains in its closed position until the coil is de-energized. The pickup can be adjusted in a range of approximately 30 to 80 percent of the rated voltage by varying both the armature kickout spring force and the armature gap.

The dropout can be adjusted in a range of about 20 to 25 percent of the rated voltage by the kickout spring.

Overload and Jamming Relay

Overload and jamming relays, Fig. 1(G) are d-c magnetically operated by means of a series or copper strap wound coil. This coil is supported on a short length of heavy copper tubing that provides some damping action and prevents the relay from operating on harmless transient currents.

Between the core and the core pole-face, a 0.187 in. thick nonmagnetic spacer is assembled; the thickness of the spacer is such that the relay will give certain pickup and dropout characteristics.

Coils and stud assemblies are available for currents ranging from 75 to 625 amperes. The continuous current ratings of the series coils are usually based upon a current density of 2,000 amp per sq in. in the copper section.

These relays are designed to provide overload and jamming protection for the drive motor. They are extensively used on marine controllers to prevent damage to hoist, windlass, and capstan equipment when the load or cable jams. They are also used to provide almost instantaneous magnetic overload protection for d-c general purpose motor controller applications.

When a d-c current that is within the pickup range flows through the series coil winding, the armature is attracted toward and seals against the core pole-face. The pickup current value is determined by the armature kickout spring force and the armature gap. The armature gap is generally expressed in terms of the main contact gap on the calibration curves. The main contact gap setting is more convenient to use and provides a more accurate method of setting the armature gap. The pickup value may be varied in a range of approximately three to one by adjusting both the kickout spring force and the main contact gap.

The current value at which the armature drops out or is released can be varied in a range of approximately 1.8 to 1, or between approximately 1,350 and 750 ampere-turns by varying only the armature kickout spring force. The main contact gap has no effect on the dropout value.

When used only for overload protection, the relay is calibrated for the desired pickup current by adjusting both the armature kickout spring force and the main contact gap.

For jamming applications, the relay is usually calibrated to operate with a definite ratio of pickup current to dropout current. This ratio is often 2 to 1. As the dropout current value can be adjusted only by varying the kickout spring force, this setting is always made first. Next, the desired pickup current value is obtained by adjusting

only the size of the main contact gap.

For a well engineered relay design, special attention must be given to the force characteristics of the armature kickout spring. The spring force length characteristics must be coordinated with the magnetic force characteristics. For practical purposes, the main contact gap can be used as a common base for the two forces.

The force characteristics of jamming relay armatures with springs of poor and good designs are compared in Fig. 13. The ratio of magnetic force to the contact gap for 1,300 ampere-turns is identical in both curves. For the poor spring, the curve for the net force acting upon the relay armature is just below and almost parallel with the O force axis. This curve crosses the O axis at such a small angle that slight variations in current may cause the relay to pick up over an indefinite range rather than at one specific current value. Also, this curve is so flat that under some operating conditions, the armature may just "float" between its open and closed positions. This characteristic could almost be used for a regulator where the armature movement is desired to be proportional to the voltage or current. To obtain such a steep spring characteristic, the spring would generally be short, of small diameter, a few turns, and wound with a relatively large diameter wire.

For the spring of good design, the net force curve intersects the O force axis at a decisive angle so that the relay always picks up at a specific current value. Also, the net force acting upon the armature increases at such a rapid rate that once the armature starts to move, it does not stop until it seals against the core pole-face. To obtain such a flat spring force characteristic, the spring would normally be long, of large diameter, and have many turns of small diameter wire.

While the armature kickout spring is a small part of a complete relay assembly, its design often makes the difference between satisfactory and unsatisfactory operation.

Construction Features

KNIFE-EDGE BEARING. Knife-edge bearings are used throughout this entire line of relays and Timetactors. This type of bearing is self-aligning and permits the armature to seal perfectly flat on the frame pole surfaces; it withstands millions of operations and is not greatly affected by dust or dirt. To reduce the hazard of foreign matter falling into the bearing, it is located at the top of these devices.

FRAME AND ARMATURE. For uniform magnetic properties, the frames, cores, pole-faces, and armatures are made from commercially pure iron. To relieve bending and machining stresses, all parts are annealed. To secure uniform magnetic characteristics, timing relay or Timetactor magnetic circuit parts are annealed in a hydrogen atmosphere. This treatment not only relieves mechanical working stresses, but also removes some of the impurities in the iron, such as carbon and sulphur.

The ground surfaces of the armature, frame, and core are plated with hard chromium. In addition to good protection against corrosion and mechanical wear, the chromium surface also provides some shim action and insures that the time delay period or dropout value will not vary with operation.

CONTACTS. Both the main and auxiliary contacts have silver faces to provide low contact resistance and positive electrical contact. Moderately burned and blackened silver contacts usually do not require replacement or dressing as the discolored surface is normally still a good conductor.

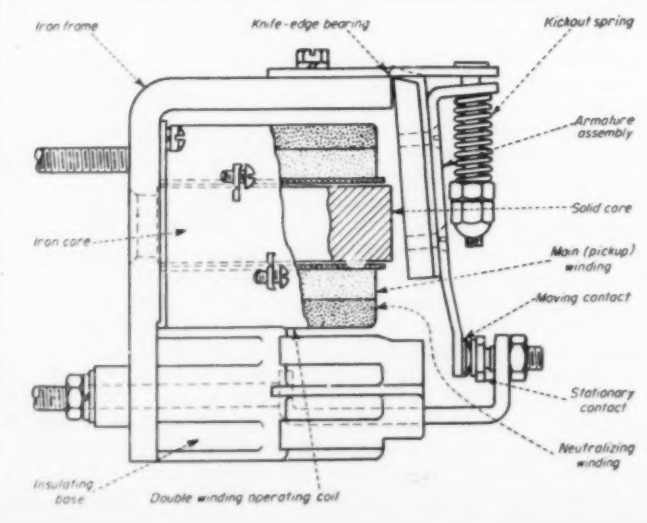
UNIT CONSTRUCTION. Each of these devices is a self-contained unit. All parts are aligned during assembly and do not depend upon clearance in the panel mounting holes for the device alignment. The auxiliary contact assemblies, ordinarily added as accessories beneath or beside the device, are specially provided for and do not require additional mounting space.

AUXILIARY CONTACTS. The stationary and moving auxiliary contact parts

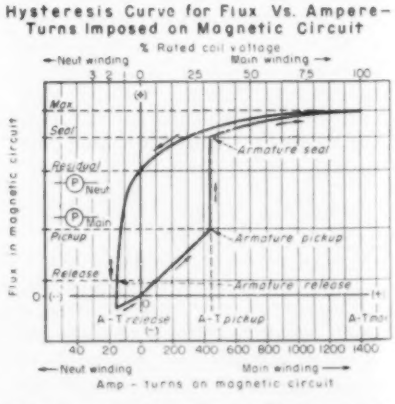
DIRECT-CURRENT MAGNETICALLY

Construction

Plugging Relay



Characteristics



1.25 lb. spring force "F"---pickup 450 A-T---release-14 A-T
3.75 lb. spring force "I"---pickup 800 A-T---release 8A-T
Release voltage practically unaffected by normal temperature changes as neutralizing winding wound with low temperature coefficient of resistance copper-nickel wire

are the same for all device assemblies. This feature is particularly desirable in reducing the number of different parts in the spare part inventory.

FINISHES. All parts and hardware are finished to withstand corrosion. The frame and armature parts are plated before the pole-face surfaces are ground. For uniform appearance and additional protection, the parts are finally finished with a coat of paint. This combination finish satisfactorily withstands a 200 hr salt spray test.

MAINTENANCE. To facilitate servicing and maintenance, the armature, moving contact, and coil assemblies are readily removable from the front of the device.

Conclusion

Application engineers have utilized and combined the features of these seven specific devices for applications other than those discussed. For instance, a neutralizing winding added to the single coil winding of an inductive time delay relay makes it possible to secure an electrically adjustable and shorter time delay period. This addition is advantageous in hoist controllers as the neutralizing winding can be inserted into the circuit to provide a faster light hook lowering operation.

The Timetactor assemblies for definite time limit acceleration can be easily modified for current limit acceleration. The addition of a nonmagnetic shim between the armature and frame, and wiring the neutralizing winding so that its magnetic field assists the main coil winding, is all that is necessary to adapt the device for current limit operation. This type of acceleration is necessary for starting high inertia loads.

The construction and characteristic curves of each device, along with typical controller application diagrams utilizing these devices, are tabulated in the following charts.

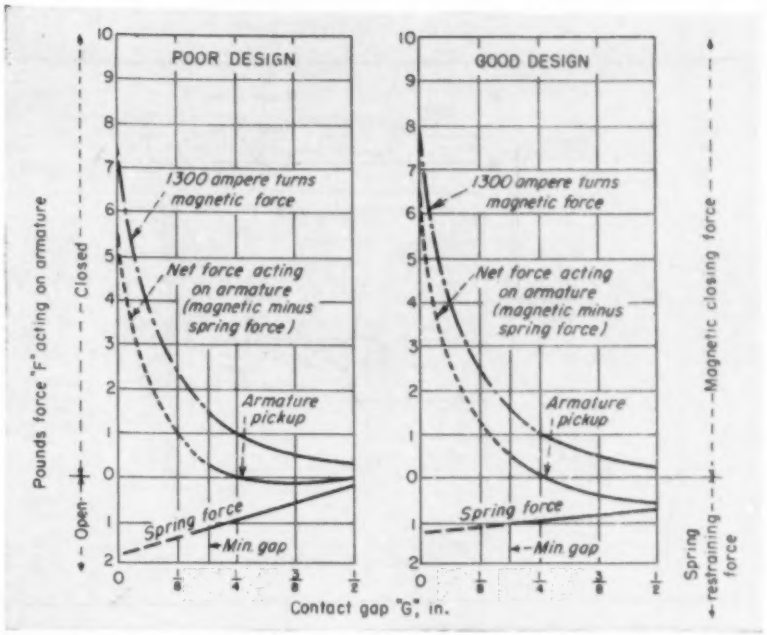
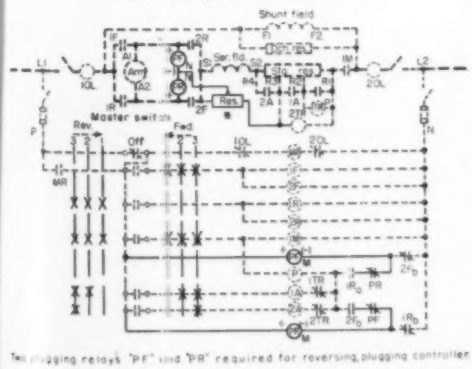

POOR DESIGN
GOOD DESIGN
1300 ampere turns magnetic force
Net force acting on armature (magnetic minus spring force)
Armature pickup
Spring force
Min gap
Pounds force "F" acting on armature
Open — Closed
Magnetic closing force — Spring restraining force
Contact gap "G", in.

Fig. 13—Comparison of jamming relay armature force characteristics with springs of poor and good designs. With good spring, relay picks up at a precise current value.

OPERATED DEVICES

Application

Reversing, Plugging Controller for D-c Compound Wound Motor



Two plugging relays "PF" and "PR" required for reversing plugging controller.

* Plugging contactor "P" can be adjusted for closing before motor reaches zero speed by moving slider on resistor towards "R2"

Operation

PLUGGING A D-C MOTOR. In plugging a d-c compound wound motor, the polarity of the voltage applied to its armature is reversed while running. Power from the line is utilized to decelerate and stop the motor. All steps of starting resistor *R2-R4* and the additional plugging resistor step *R1-R2* are inserted in the armature circuit to limit the current during plugging. After being plugged to a stop, the motor can be accelerated in the opposite direction in the normal manner.

Plug Forward *PF* and Plug Reverse *PR* relays control the plugging. Each has a main winding to close and a neutralizing winding to release its armature. After a relay has been closed magnetically and its main winding has been de-energized, the residual magnetism in the relay prevents the armature from being released. The armature is released by energizing the neutralizing winding with a voltage of the correct polarity and of sufficient magnitude to neutralize the residual magnetism.

At standstill, with the master switch in Off position, the main windings of the *PF* and *PR* relays are energized. Moving the master switch to its Forward position opens the auxiliary contact $2F_B$, which de-energizes the main winding PF_M of the forward plugging relay. Since the neutralizing winding PF_N is in parallel with the motor armature and the armature IR drop has the correct polarity to neutralize the residual magnetism, the relay *PF* drops out immediately and energizes the plugging contactor *P*. Closing contact *P* shorts out the plugging section of the resistor. The controller then accelerates the motor in the forward direction. Inductive time delay relay *1TR* and *2TR* control the automatic shorting out of the resistor steps at definite time intervals.

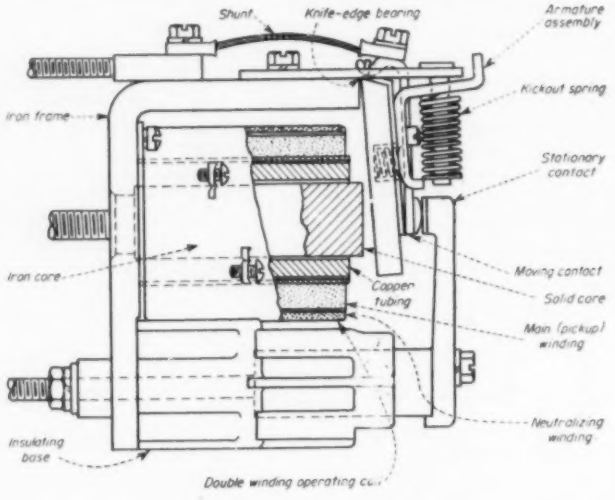
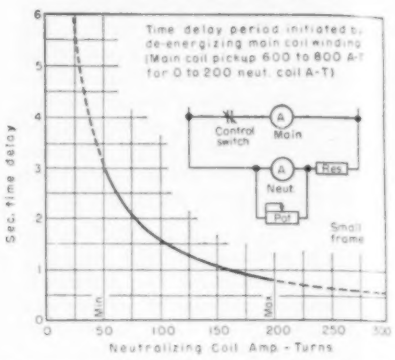
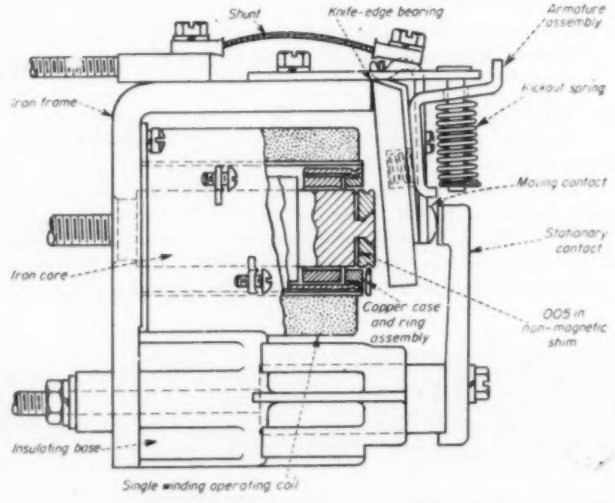
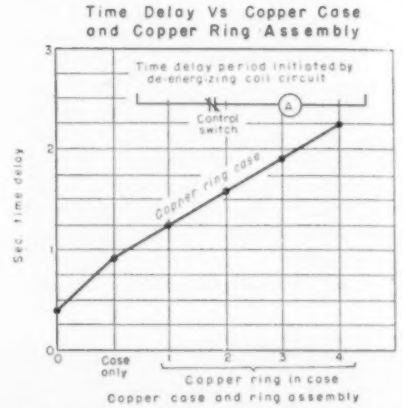
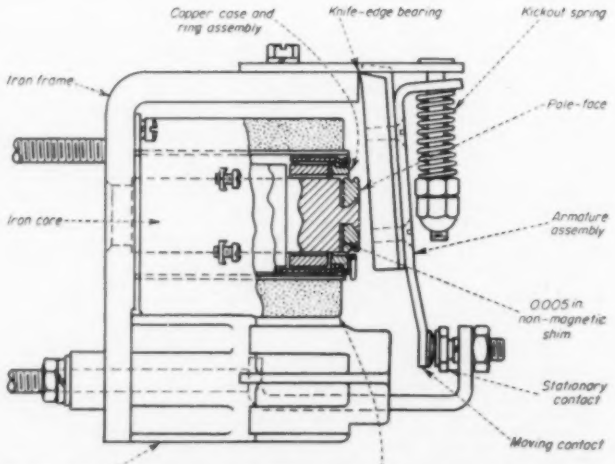
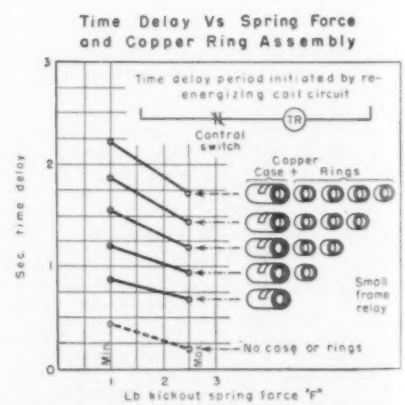
Moving the master switch to the Reverse position while operating full speed forward opens the forward contactors *1F* and *2F*, and closes the reverse contactors *1R* and *2R*, thus the main winding PF_M of the forward plugging relay is energized and its contact *PF* opens to drop out contactors *P*, *1A*, and *2A*. The motor counter emf and line voltage are then in series, but the combined starting and plugging resistance limits the motor armature current to a safe value.

The direction of the current through the neutralizing winding of the reverse plugging relay *PR* assists the residual magnetism in holding the relay armature closed until the speed of the motor decreases to almost zero. At this point, the motor counter emf is almost equal to the armature IR drop. When the counter emf becomes greater than the IR drop, the current through the neutralizing winding PR_N reverses and the magnetic field opposes the residual magnetism. Relay *PR* then drops out and closes its *PR* contacts. Plugging contactor *P* recloses and the motor is accelerated in the reverse direction.

Contactor *MR* provides low-voltage protection for the control circuit.

(*Continued on page* 190)

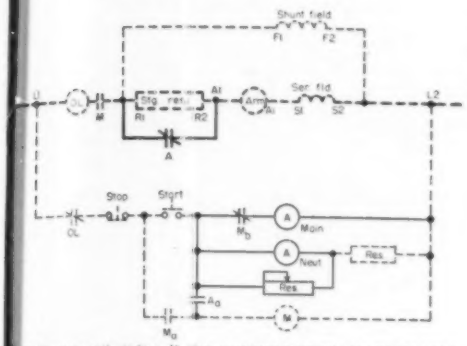
Direct-Current Magnetically Operated Devices (continued)

	Construction	Characteristics
Timetactor, Double Winding Coil		 Time range normally limited to ¾ to 3 sec. Time periods in excess of 3 sec. not recommended as a decrease in line voltage will increase the time delay period. Time periods less than ¾ sec. require relatively high neutralizing ampere-turns. This in turn increases the main coil pickup voltage.
Timetactor, Single Winding Coil		 Brass ring case available for decreasing time delay period approximately ½ second No adjustment between copper rings 3 lb main contact force "F" (No spring adjustment) Pickup approx 700 A-T—Dropout 15 to 25 A-T
Time Delay Relay		 Time delay period approximately ¾ second longer when coil circuit shorted Spring adjustment between copper rings Min. spring force "F"—— pickup 600 A-T—dropout 15 A-T Max spring force "F"—— pickup 1000 A-T—dropout 30 A-T

Application

Operation

Non-Reversing, One-Step Starter for D-c Compound Wound Motor



After the main coil winding "A_m" has once been energized, the definite time limit acceleration period is initiated when the line contactor "M" auxiliary contact "M_b" is opened.
The time delay period can be adjusted by varying the neutralizing coil "A_n" ampere-turns.

DEFINITE TIME AUTOMATIC D-C MOTOR STARTING. Since the armature circuit resistance of a d-c motor is inherently low, a starting device is generally required to limit the starting current and torque to safe values. Unless means are provided to limit it, the inrush current for a typical motor connected to an ample power supply may be 10 to 20 times the rated value. For constant field excitation, the motor torque is almost directly proportional to the armature current. Also, line-starting most d-c motors causes the commutator to flash over, or an excessive torque may damage the motor mechanically.

The simplest and most usual method of starting a d-c motor is to insert resistance in the armature circuit for a definite time period that is long enough to permit the motor to accelerate to a relatively high speed. As the motor armature accelerates, the counter emf increases and the armature current automatically decreases. To avoid poor speed regulation and wasting electrical energy, the resistor should be cut out of the circuit when the motor attains a speed as high as the load requirements permit.

For automatic d-c motor starting, an accelerating device is required to control the shorting out of the starting resistor. The definite time-limit method of starting is the most common method for low and medium inertia loads.

For general purpose d-c motor starters, a d-c magnetically operated Timetactor can be used to control the shorting out of the starting resistor.

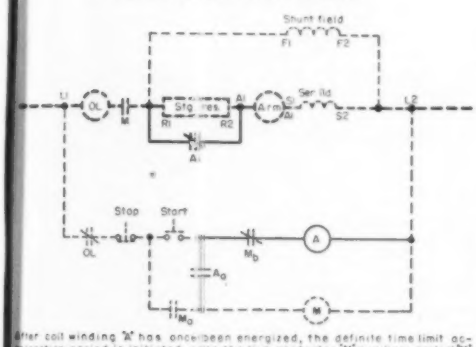
Operating the Start button energizes the main or pickup winding A_{main} of Timetactor A. Main contact A, in parallel with the starting resistor, then opens and auxiliary contact A_a closes to energize the line contactor coil M. When contact M closes, the motor starts with the starting resistor in the circuit. Auxiliary contact M_a closes to provide a circuit around the Start pushbutton so that it can be released.

Auxiliary contact M_b, on the line contactor M, opens and de-energizes the main coil winding A_{main}; de-energization of this winding initiates the time delay period; the armature of Timetactor A is released after a time delay and contact A closes to short the starting resistor out of the circuit; after which full line voltage is applied to the motor armature.

After the acceleration period has elapsed, only contactor coil M is energized in the control circuit. The neutralizing A_{neut} is used to release the Timetactor armature and for electrically adjusting the time delay period.

Motor runs until it is stopped by operating the pushbutton or by operation of the overload relay.

Non-Reversing, One-Step Starter for D-c Compound Wound Motor



After coil winding "A" has once been energized, the definite time limit acceleration period is initiated when the line contactor "M" auxiliary contact "M_b" is opened.
The time delay period can be adjusted only by adding or removing copper rings.

DEFINITE TIME AUTOMATIC D-C MOTOR STARTING. Single winding coil type of Timetactor can be used to control the starting of a d-c compound wound motor when a shorter accelerating period is not objectionable and where remote or precise electrical time delay period adjustment is not required.

To start motor, operation of Start button energizes Timetactor operating coil A, which closes its armature to open the main contact A that is in parallel with the starting resistor. Opening contact A inserts the starting resistor in series with the motor armature to limit the motor current. Auxiliary contact A_a closes and energizes line contact coil M, which closes the line contacts M and applies reduced voltage to the motor armature and full line voltage to the shunt field. The starting resistor limits the inrush current and prevents the motor from developing excessive torque. A normally open auxiliary contact M_a closes to provide a holding circuit around the Start button when it is released. Normally closed auxiliary contact M_b on the line contactor M opens to de-energize Timetactor coil A to initiate the time delay period.

The copper case and ring assembly inside the Timetactor coil delays the decay of the magnetic field for a few seconds after the operating coil has been de-energized. After a suitable accelerating period, contact A closes and shorts out the starting resistor, thus applying full line voltage to the motor armature.

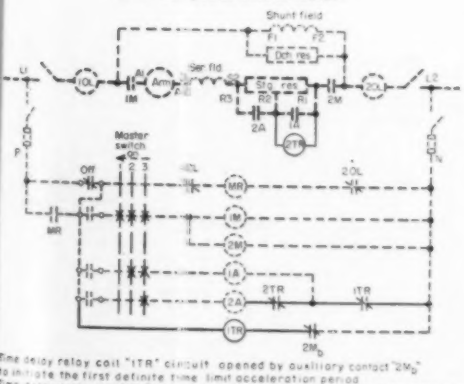
Motor runs until contactor coil M is de-energized by line voltage failure, functioning of the overload relay, or operation of the Stop pushbutton.

In this circuit, the Timetactor is electrically interlocked with the line contactor M so that the Timetactor main contacts A only close a circuit and are never required to interrupt current.

Since the line contactor coil M is energized through its own auxiliary contact M_a, this circuit provides low-voltage protection. Should the power supply fail, the Start button must be pushed to restart the motor.

Since the motor shunt field is usually wound with a large number of turns of wire, it is inherently highly inductive and should always be connected so that it has a discharge circuit; the induced voltage is thus prevented from building up to a dangerous value when the field is de-energized. In the accompanying circuit diagram, the discharge path of the shunt field is through the armature and series field circuit.

Non-Reversing, Controller for D-c Compound Wound Motor



Time delay relay coil "1TR" circuit opened by auxiliary contact "$2M_b$" to initiate the first definite time limit acceleration period.
Time delay relay coil "2TR" circuit shorted by main contact "1A" to initiate the second definite time limit acceleration period.

NON-REVERSING DEFINITE TIME LIMIT CONTROLLER. Master relay MR in conjunction with manually operated master switch provides low-voltage protection. Relay coil MR is initially energized through the reset contact on the master switch. When master switch is moved to any starting and running position, the MR contact provides a circuit for energizing the MR coil and the control circuit. If an overload relay contact in the MR coil circuit opens, the MR relay will be de-energized and the controller cannot be operated until the abnormal condition is corrected, the overload relay contact reclosed and the master switch returned to Off position.

Moving the master switch handle to position 1 energizes contactor coils $1M$ and $2M$; line contacts $1M$ and $2M$ close and the motor is started with all of the starting resistor $R1$-$R3$ in series with the motor armature. The starting resistor limits the current through the motor armature. The voltage drop across the $R1$-$R2$ section of the starting resistor energizes the operating coil of the $2TR$ inductive time delay relay. An auxiliary normally closed contact $2M_b$ on the $2M$ line contactor opens and de-energizes the operating coil of the inductive time delay relay $1TR$.

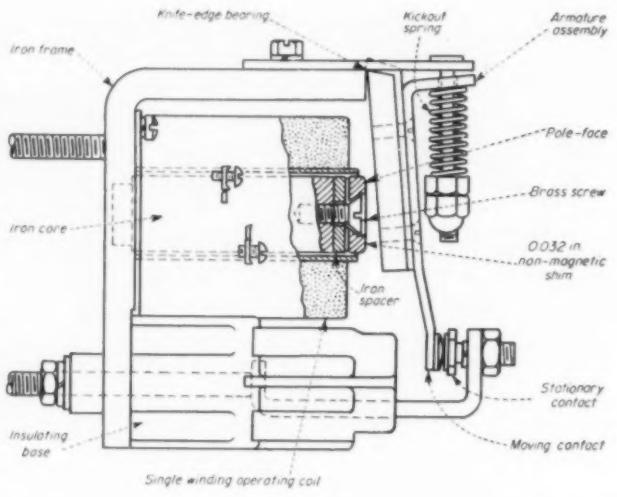
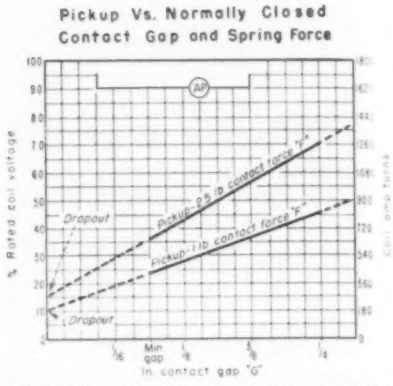
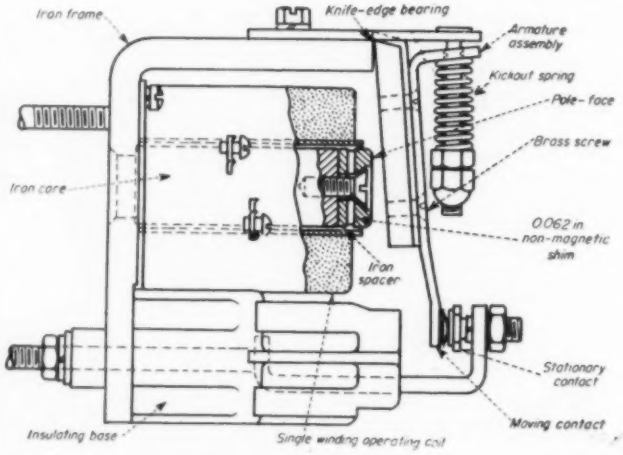
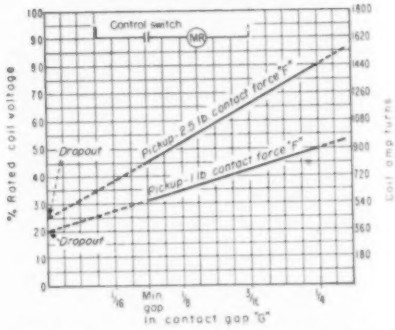
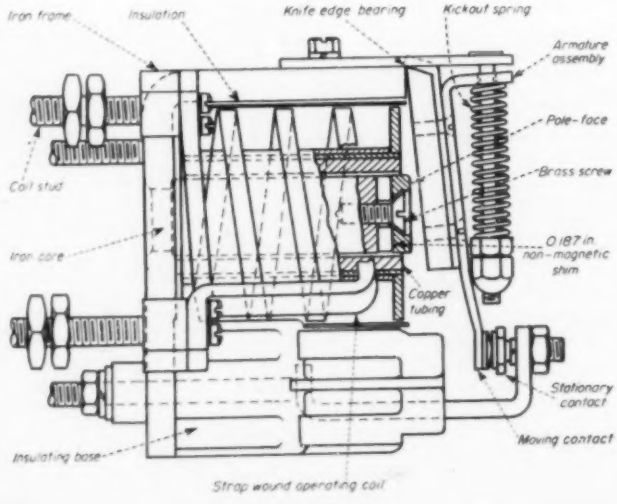
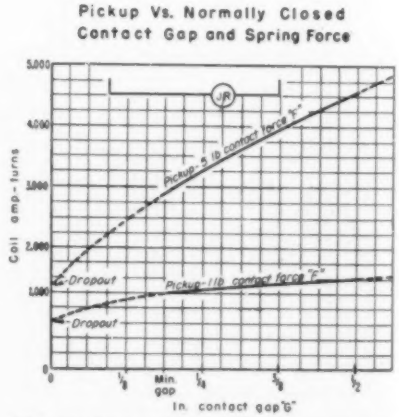
When the master switch handle is moved to the second point, the first accelerating contactor $1A$ is energized if sufficient time has elapsed since coil $1TR$ was de-energized and relay $1TR$ has timed out. Closing of contacts $1A$ shorts out the first step of the starting resistor and the motor accelerates to a higher speed. Closing of contacts $1A$ also shorts out the operating coil of the inductive time delay relay $2TR$ to initiate the second time delay period.

When the master switch handle is moved to the third point, the second accelerating contactor $2A$ is energized if timing relay $2TR$ has timed out. Closing of contact $2A$ shorts out the remainder of the starting resistor and full line voltage is applied to the motor.

Motor can be operated continuously at reduced speeds on points 1 and 2 if desired. Regardless of how fast the master switch is operated, the inductive time delay relays $1TR$ and $2TR$ automatically prevent the motor from accelerating faster than the minimum preset time periods. When master switch is moved rapidly to the third position, the timing relays provide two distinct accelerating periods. Shorting out relay coil $2TR$ by accelerating contact $1A$ eliminates one auxiliary contact that ordinarily is required to control this relay.

(Continued on page 192)

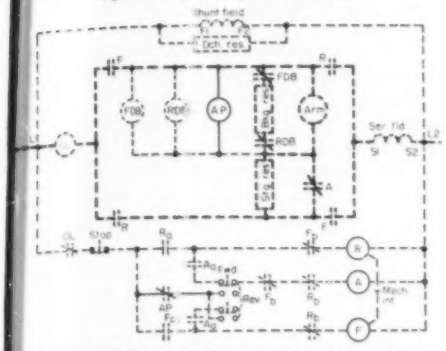
Direct-Current Magnetically Operated Devices (continued)

	Construction	Characteristics
Anti-Plugging Relay		 Pickup voltage for coil winding at temperature of 25°C. Min. and max. contact forces "F" set only when contact gap "G" is adjusted for 1/4 in.
Control Relay		 Pickup voltage for coil winding at temperature of 25°C. Min. and max. contact forces "F" set only when contact gap "G" is adjusted for 1/4 in.
Overload and Jamming Relay		 Pickup amp-turns practically unaffected by normal variations in series coil temperature. Min. and max. contact forces "F" set only when contact gap "G" is adjusted for 1/4 in.

Application

Operation

Reversing, One-Step Starter with Dynamic Braking for D-c Motor



Anti-plugging relay "AP" contact "AP" opens when the counter emf of the motor reaches approx. 50 % of the rated voltage. "Fwd" and "Rev" pushbuttons ineffective until contact "AP" recloses when the motor armature decelerates to approx. 10% rated speed.

ANTI-PLUGGING PROTECTION. Unless its armature current is limited by a plugging resistor or other effective means, a d-c motor is likely to be damaged by plugging it to a quick stop. To prevent plugging, an anti-plugging relay having a low dropout characteristic can be used for general purpose d-c reversing controllers.

Forward *F* and Reverse *R* contactors have two normally open contacts on the upper end of their armatures and one normally closed contact on the lower end for dynamic braking. The contactor armature is pivoted at its midpoint and has upper *F* or *R* and lower *FDB* or *RDB* operating coils. This construction mechanically interlocks the upper and lower contacts.

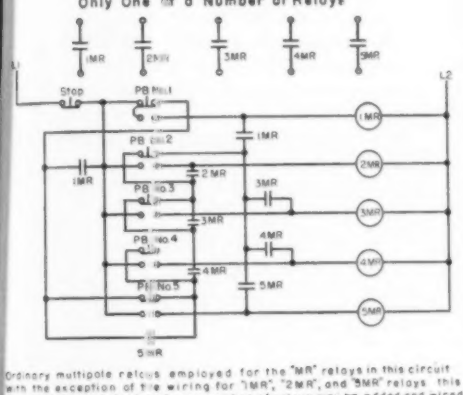
The forward and reverse contactors should always be mechanically interlocked so that not more than one set of contacts can be closed at the same time. Operating the Forward pushbutton energizes Timetactor coil *A* and its main contact *A* opens to make the starting resistor effective. Auxiliary contacts A_a close and the forward contactor coil *F* is energized The pushbuttons are interlocked so that either contactor operating coil is prevented from being energized by the simultaneous operation of both buttons. When coil *F* is energized, the two normally open main contacts *F* close and the forward normally closed dynamic braking contact *FDB* opens. The motor now starts with reduced voltage applied to the motor armature. Opening the forward auxiliary contact F_b de-energizes Timetactor coil *A* and initiates the time delay period. After a few seconds, contact *A* closes and shorts out the starting resistor. The motor then operates with full line voltage applied to the armature.

Since the contactor lower coils *FDB* and *RDB* are in parallel with the motor armature, they are energized by the counter emf generated by the motor. Even when these coils are eventually energized with full line voltage, the pull of the lower magnet is not sufficient to operate the contactor since the upper magnet pull is much greater with the armature in the upper seated position. When the stop button is operated, the dynamic braking contact *FDB* is snapped closed and held closed magnetically until the armature voltage decreases to a very low value. Connecting the lower operating coils in this manner provides fast closing of the braking contacts, good contact force, and minimizes bounce; also, it prevents the opposite direction contactor from being closed until the motor is almost at standstill.

The anti-plugging relay coil *AP* is energized by the counter emf of the motor. When the motor accelerates to approximately 50 percent of rated speed, the voltage is sufficient to operate the *AP* relay. Normally closed contact *AP* in the pushbutton circuit opens and renders the Forward and Reverse pushbutton ineffective. Control contact *AP* recloses only when motor is decelerated to almost standstill.

With the forward and reverse contactors described, the anti-plugging relay *AP* is not strictly required. When the directional contactors are separate devices, however, the anti-plugging relay is essential.

Control Circuit for Selecting Only One of a Number of Relays



Ordinary multipole relays employed for the "MR" relays in this circuit with the exception of the wiring for "1MR", "2MR", and "3MR" relays. This circuit is symmetrical and any number of relays may be added and wired similar to the "3MR" relay.

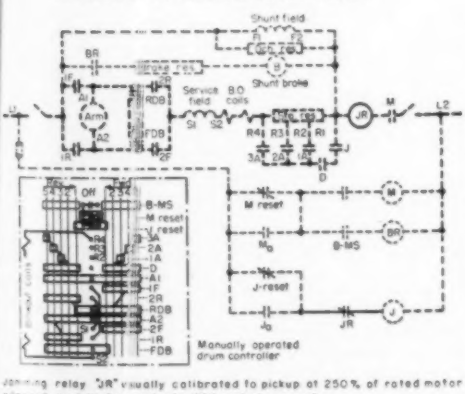
SELECTION AND INTERLOCKING. Control relays are applied in many ways to provide protective and interlocking features in control schemes. With manually operated master switches and drum controllers, relays practically are always required to provide low-voltage protection. This type of electrical interlocking always requires that the operator return the operating handle to the Off position before restarting in the event of voltage failure or operation of the overload relay. Also, the relay can provide sufficient interrupting capacity for the entire control circuit.

Multi-speed control and special circuits sometimes require that only one of a number of relays be in operation at a particular time. The accompanying circuit for selecting only one of a number of relays uses momentary contact pushbuttons for a part of the electrical interlocking. The basic principle of this scheme is that the specific relay selected must have its coil holding circuit through one of its own normally open contacts and through the upper normally closed contacts of all other pushbuttons except its own. Also, a by-pass contact must be in parallel with its own pushbutton contact to provide a positive circuit to the coil while the moving contact element of the pushbutton is returning from its lower to its upper contacts after the button has been released.

If a relay is already energized, operation of any other pushbutton will de-energize it and select and energize the particular relay desired. Mechanical interlocking between relays and additional electrical interlocking can be added as desired for specific applications.

With the exception of the wiring for the first, second and last relays, the scheme is symmetrical. Any number of relays can be added and connected in a manner identical with that of the third and fourth relays.

Reversing Controller with Jamming Protection for D-c Compound Motor



Jamming relay "JR" usually calibrated to pickup at 250% of rated motor current, and to dropout at 125% rated current.

JAMMING AND OVERLOAD PROTECTION. Capstans and windlasses are provided with jamming protection to maintain tension in a rope, cable, or chain should the load jam or excessively overload the motor. Maintaining tension on the rope or cable often frees the load and permits resumption of normal operation. Also, a jamming relay automatically reduces the drive motor torque to a safe value.

In the accompanying circuit, jamming protection is provided by jamming relay *JR*. This relay is operated by a series coil and is normally calibrated to pick up or close the relay armature at approximately 250 percent of rated motor current and to drop out at about 125 per cent of rated current.

The dynamic braking resistor in this type of controller also serves as an armature shunting resistor to permit smooth and easy taking up of the slack in the rope or cable. The braking resistor is designed primarily for desired armature shunting characteristics; the braking characteristics are secondary. To hold the load securely in the Off position, a magnetically released mechanical brake is used.

With the controller handle in the Off position, the line contactor *M* and the jamming contactor *J* operating coils are energized through their respective reset contacts on the manually operated drum controller. In the Off position, the mechanical brake is set since the brake relay coil *BR* is not energized.

Moving the controller handle to the first point in the Forward or Reverse direction closes contacts *1F* and *2F* or *1R* and *2R*. The motor then starts with the armature shunted and with all the starting resistance in the circuit. The motor speed and torque are lowest on this point. Advancing the drum through the remaining points cuts out more starting resistance, thus increasing the motor torque and speed. When all starting resistance is cut out, the motor operates on full line voltage. To avoid excessive current peaks that might cause the relay *JR* to operate, the operator should pause long enough at each running position to permit the motor to accelerate.

Sustained current surges in excess of 250 percent of full load motor current will operate the relay *JR*. Opening the *JR* contact de-energizes the jamming contactor *J* to open the contact *J* and inserts all the starting resistance in the circuit regardless of the position of the drum. Thus the motor armature current is reduced to a safe value of about 125 percent of the full load value with the armature stalled. To re-accelerate the motor, the controller handle must be moved to the first point to reclose the Reset *J* contact and the contactor *J*. Before jamming contactor *J* can be reclosed, the jamming relay *JR* must drop out and reclose its *JR* contact. Relay *JR* can be reset only by the load freeing itself and reducing the current to a value below 125 percent of rated current, or by moving the drum to the Off position. The motor can then be restarted and torques up to 250 percent applied to the load without retripping the *JR* relay.

TECHNICAL NEWS

SCIENTIST PREPARES to insert plug from NBS failure-prediction unit into multi-point connector of equipment under test. By rotating stage selector knobs, tubes are checked quickly for decrease in tube transconductance. Warning light flashes if tube is below safe limit. Small knobs in center permit sensing capacitor leakage.

How to Detect Failing Electronic Tubes

NUMBER ONE PROBLEM with complicated electronic gear is how to predict tube failure so that an ailing vacuum tube can be replaced before it has a chance to become inoperative. In the past few years engineers have tried to circumvent this problem with more reliable tubes, more reliable circuits (*PRODUCT ENGINEERING*, June 1952, p. 175 et seq.), or with additional circuits to monitor the functionally necessary ones. But what users have wanted is a simple method that can be performed by unskilled labor with simple equipment. A new device developed by the National Bureau of Standards seems to fill the bill.

With the NBS failure-prediction unit, a maintenance man plugs the portable unit into the slightly modified equipment to be checked, turns a multiple-point selector switch, and a red light flashes a warning to identify stages or components that have deteriorated below safe levels. In accelerated aging experiments on military radio receivers, NBS was able to predict most failures many hours before they actually occurred.

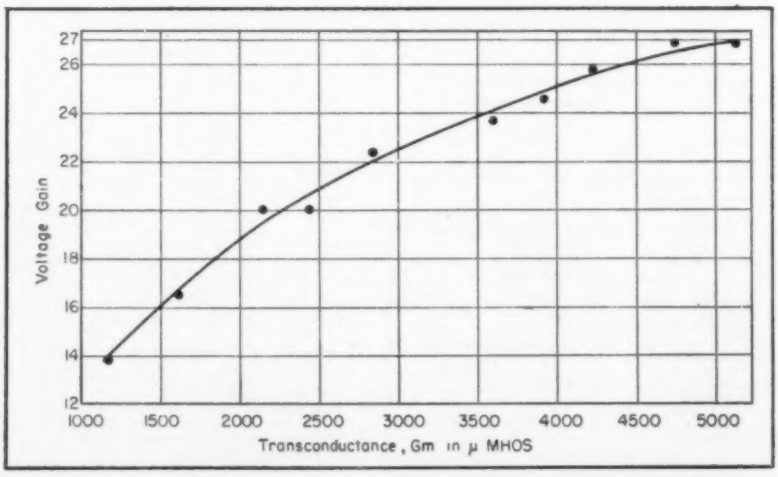
▶**How it is done.** This device depends primarily on sensing decrease in tube transconductance of critical stages since in multi-tubed equipment overall performance usually masks the performance decrease of one stage. To do this, the suspected tube is operated as a resistance-coupled amplifier on which a 3,000-cycle signal is applied, and the voltage gain is then measured to see if it has fallen below a predetermined level. The test also detects changes in components other than the tube if the changes affect the gain of the stage. In addition, the unit can check capacitors for leakage and make voltage and amperage measurements, although the usual failure in electronic gear is a tube failure detectable by the voltage-gain check.

Components of the NBS detector include: a 3,000-cycle oscillator, voltage sensing circuits, leakage detection circuit and an alarm light. As the main selector switch is rotated to check the gains of various stages of the equipment under test, different predetermined levels of audio signals are applied to the grid of each stage. Each input signal is preadjusted so that if the gain of the stage has changed by more than a safe amount, the voltage sensing circuits actuate the alarm light.

While it takes only a few seconds to rotate the selector switch and discover any weak stages, NBS feels that switching could be speeded up and made automatic by the use of stepping-type switches.

A separate three position switch on the device permits capacitor leakage sensing, and voltage-and-current sensing.

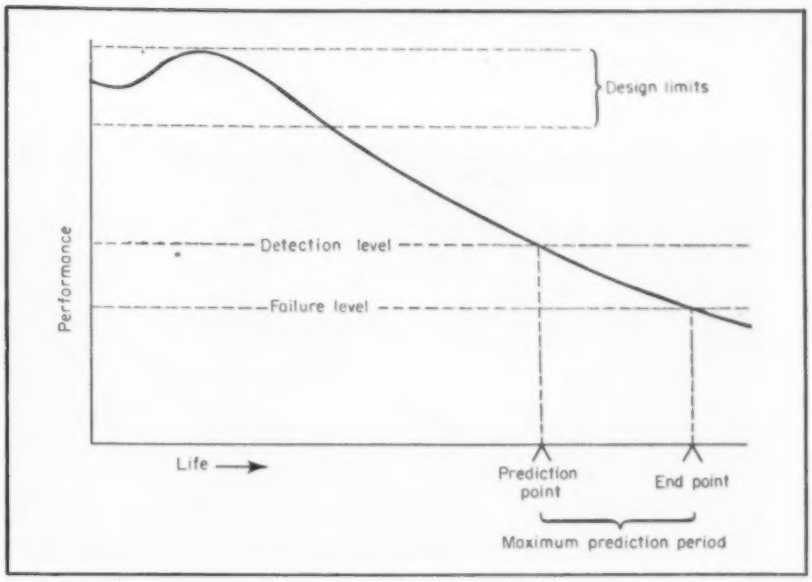
▶**Test results.** Typical of what the failure-prediction unit can do is revealed by data the Bureau obtained on a 1,000 hr accelerated aging test of six military radio receivers that had been modified for the plug-in tester. To accelerate failures, NBS scientists cycled the temperature of the com-



TEST CURVE OF TYPICAL RECEIVER TUBE shows decreasing test voltage corresponding to decreasing voltage gain. Overall performance of unit was not affected by this decreasing performance until test voltage had fallen to half its original value, by which time the deteriorating stage was ready to cause complete failure.

ponents between 10 C and 120 C with a period of 15 min. They maintained voltages at 15 percent above design values, and simulated switching transients by periodically raising plate voltages to 150 percent of normal for one second. Prediction checks were made at 5-hour intervals.

Here's what happened: The equipment suffered 79 tube failures during the test. Eighty percent or 65 were of a gradual and predictable nature, the result of either low transconductance or gassiness. The remaining 14 were so-called unpredictable failures evenly divided between open heaters and shorts. The detector unit spotted 58 of the 65 predictable tube failures many hours before they actually failed. Of those failures not predicted, two were in stages that were not checked; four were in a single stage where parasitic oscillations interfered with measurement; and the remaining failure was masked by an overloaded resistor. Failure of components other than tubes was negligible.



CURVE REPRESENTING CHANGE OF PERFORMANCE LEVEL with service life of a vacuum tube, resistor, capacitor or subassembly. Purpose of NBS detector is to sense deterioration of component before it reaches failure level.

▶ **Required changes in equipment.** To make the test, the electronic gear required slight modifications. First step involves analyzing the equipment to locate circuits sensitive to weak and gassy tubes. Wiring in these stages is modified to allow provision for breaking grid and plate return leads so that the audio signal may be inserted and the gain measured. Final step is to connect the added wiring to a multipoint connector into which the plug from the failure prediction unit may be inserted. Circuit changes entail the use of about 7.5 percent additional components, mostly capacitors and r-f chokes.

While NBS scientists are enthusiastic about their failure predictions they issued these precautions: the usual tube failure due to predictable causes runs around 50 percent rather than the 80 percent of their controlled test. Reason: shock and vibration cause unpredictable failures and these factors were not included in the NBS study. In addition, the scientists feel that design engineers can improve on this equipment and can develop practical techniques for semi-automatic checks to detect incipient failures.

But even with these limitations, the indicator looks promising for such applications as testing aircraft electronic systems that have as many as 2,000 vacuum tubes and where tubes fail at a rate better than one every 12 hours; and in giant computers that use over 5,000 tubes with a failure every hour can be statistically predicted.

Foreign Tools Impress Visitors At British Show

LONDON—A display of over 2,500 different machine tools at the International Machine Tool Exhibit held here emphasized that Continental manufacturers are making a concentrated effort for a share of the big American machine tool market. Observers noted these significant trends on continental machines:

- Widespread use of electronic control devices.
- Almost universal use of copying attachments.
- Development of new copying milling machines, carbide grinding machinery and profile grinders.
- Increased machine rigidity, higher spindle speeds, and wider use of antifriction bearings for better utilization of carbide tooling.
- Increased use of flame hardened ways.
- A switch from scraping to slideways grinding and even slideway milling.

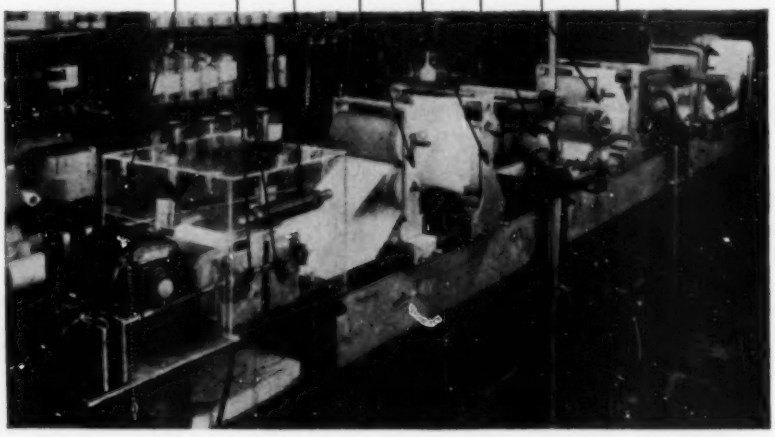
Particularly impressive were German, Swiss and British tools. The German equipment was far advanced in design and made extensive use of electronic controls to simplify operation. British equipment was outstanding for its modern but relatively simple design and low price, below most competitive machine tools.

Design Awards for Engineering Students

IN THE CURRENT BATTLE to alleviate the shortage of engineers, industry has come up with a number of schemes aimed at making the profession more attractive to high school and college students and to maintain student interest in engineering. Typical of these plans is the Design Award Program recently announced by Heli-Coil Corporation, Danbury, Conn.

To reward engineering undergraduates' ingenuity and inventiveness, the company is offering $1800 in prizes for unique new design applications of their product, the Heli-Coil thread insert. Students desiring to enter the contest first send an application to the company and receive engineering data and full information on the contest. They then can submit an entry. Each entry must contain a sketch of the design with a brief description. While a student may submit any number of entries, he can win only one prize.

Judges for the competition include design magazine editors, educators, industrial designers, and industrialists. Entries must be submitted by December 31, 1952, to be appraised on January 21, 1953.



CONTINUOUS laboratory apparatus for making ECR recording paper impregnates paper stock at room temperature in three aqueous baths. In first two baths, Benzidine is precipitated in the paper as the highly soluble sulfate. Inorganic salts that act as buffering agents and electrolytes for electrical conductance are added in the third bath. Paper is then adjusted to proper moisture content and wound into rolls which are sealed in polyethylene bags and stored in metal containers.

Benzidine Marks New High Sensitivity Recording Paper

WASHINGTON—The Naval Research Laboratory, Office of Naval Research, has developed a new electrolytic, electrochemical paper with high sensitivity, wide dynamic range, and capable of fine recording definition. The paper also has good wet strength, shelf life, and aging properties.

In the new material, Benzidine is used as the marking agent to form a blue line that has high optical contrast with the light buff background of the paper. With previous papers, the intensity of the recorded line varied as the applied electrical signal.

With respect to definition, NRL's new ECR paper has a dynamic range of 26 DB at a stylus speed of 2.95 in. per sec. NRL arbitrarily chose the minimum electrical value, but the maximum value is the level where appreciable spreading and blooming of the mark occurs.

Scientists report that they were unable to detect any appreciable fading of the trace even when the recording was stored in an atmosphere with a 100 percent humidity and a temperature of 85 F.

▶ **Precautions.** NRL pointed out that electrical properties may differ depending on the varying characteristics of recorders and specific applications. They suggest these precautions when using ECR paper:

1) Use a chemically inert stylus material such as platinum iridium. Styluses made of steel, iron, or silver do not work satisfactorily.

2) Coat the metal parts in contact with the paper with a clear lacquer, excepting the cathode and anode.

3) Paint a white surface on the area of the recorder over which the paper travels after recording to increase the contrast between record and background since the paper is translucent when wet.

New Low-Cost Process Turns Titanium-Oxide Into Titanium

NEWEST DEVELOPMENT in the big titanium race (*PRODUCT ENGINEERING*, November 1952, p. 198) is the announcement by United International Research, Inc. that they have applied for a patent covering a process for the electrolytic production of titanium directly from titanium oxide. The company estimates that their new technique will make high purity titanium ingots available at a price close to $1.00 per pound, a cost that would compete more favorably with alloy steels selling for about $.60 per lb and even lower-priced aluminum. Currently, titanium ingots sell at $5.00 per lb.

United's process is similar in principle to the Hall process for obtaining aluminum from Bauxite. The prime material is titanium oxide instead of titanium tetrachloride which contains only relatively small percentages of the metal. And not only is the electrolyte of low cost, but no impurities build up during the process so that the electrolyte may be used over and over again indefinitely. Only addition required is sufficient electrolyte to make up for evaporation which normally amounts to about one percent in 24 hr since the electrolytic cells are covered.

▶ **High purity product.** The method produces titanium sponge of high purity not in the molten state so there is no contamination of the metal. The sponge is put into an induction furnace and melted in an inert atmosphere such as argon. As it is poured from the furnace into ingots, the metal has a purity of 0.992 to 0.995 percent.

Another factor that helps keep costs low is the fact that no magnesium is required. The currently used Kroll reduction process consumes relatively large amounts of magnesium.

United plans to license their process to one or more of the present producers of titanium. They estimate that it will take about one year to set up commercial production, after licensing agreements are completed.

45,000 Crowd Metal Exposition

EXHIBITORS at the 34th National Metal Congress and Exposition held in Philadelphia were for the most part stressing the availability of their materials, processes and equipment to the 45,000 registered visitors. But they were making plenty of qualifications so they would not repeat the mistakes of last year's show.

In 1951, materials and metal working tools were tight. Many exhibitors confidently predicted no easing in metals availability before 1955 or '56. Their reasons: heavy military requirements, lagging imports, unsettled world conditions, and government restrictions. But in January 1952, the picture changed, and quickly. With the exception of nickel, copper, tin, and a few others, metals became generally available. NPA started easing restrictions and designers found themselves ignoring parts of their material substitution programs and again concentrating on using the best material for the job.

This year exhibitors made no predic-

tions. Most of them were too busy selling. They were offering bright pictures of availability and delivery dates but with this proviso: it depends on what the Russians do.

Here's how the metal picture looked at the Metal Show:

Nickel and nickel based alloys are tight, and will continue in short supply. Strategic materials like titanium, copper, and cobalt as well as high speed alloys will remain hard to get. Other metals are available.

▶ **Steel still tight.** Steel suppliers reported they were recovering quicker than expected from the effects of the big summer strike but inventories were still not normal. Most expected normal supplies to be available by mid 1953. Warehouses indicated that they were stocking at least one size of all standard shapes and advised designers to contact local warehouse men and determine the best material available before specifying a size.

Steel structurals and plate are still tight; bar stock in the larger sizes is hard to get; while sheet and flat rolled products are generally available and may be abundant by the first of the year.

Big disappointment to many visitors was the paucity of new developments and equipment at the show. Majority of exhibitors displayed well known products and concentrated on hard selling.

Observers noticed that one trend, started in recent years, continued. Fewer and fewer metal producers are exhibiting at the show, and more and more manufacturers of processing equipment and machinery are taking their place.

This year practically all the major producers of steel, aluminum, and zinc did not exhibit. Instead there were extensive exhibits of power tools, welding equipment, heat treating equipment, machine tools, and lubricants.

Materials Exposition Scheduled for 1953

FIRST INTERNATIONAL EXPOSITION devoted exclusively to engineering materials will be held at Grand Central Palace, New York City on June 15 to 19, 1953. Called "Exposition of Basic Materials for Industry", the show will present an integrated picture of the materials fundamental to product development. Along with the show, a series of technical conferences will be conducted to discuss properties and potentialities of new materials.

Most displays will fall into two major classes: new materials and new applications for standard products such as wood, metals, alloys, plastics, ceramics, textiles, leather, rubber, cork and glass. In addition, well known materials will be shown in new forms such as laminations, coatings, and combinations. Another class of displays will feature accessories and product components.

In Small Company: New Management Plan Trains Junior Executives

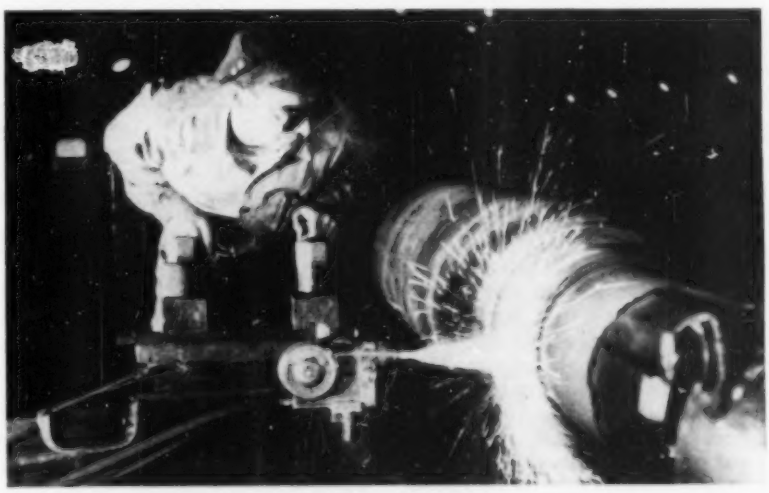
JUNIOR EXECUTIVES of the Alloy Metal Wire Company, Prospect Park, Penna., are being encouraged to take part in making top management decisions with a new group management plan the company has recently adopted. The program permits the training of junior executives for top executive jobs and at the same time improves company operation with an influx of new ideas from men who are intimate with the company's plant operation, engineering, and sales.

▶ **How it works.** Heart of the program is a Junior Board of Executives composed of nine men selected from a group of 22 eligibles including: the shop foremen, plant superintendent, assistant plant superintendent, industrial engineers, purchasing agent, sales development engineers, advertising manager, and chief accountant. Every six months the nine members of the board rate each other on the points necessary to be a good executive. The men with the four lowest ratings are dropped from the board and four new members are chosen from the eligibles. Having been dropped does not bar a man from future participation for a place on the board.

Meeting every other week, the board elects its own chairman and secretary for a six month period. At the meetings they discuss operational ideas and suggestions for bettering the company's products. Any one of the 22 eligible members may submit a subject for the board's consideration. The board then sets up a committee to make a detailed study and recommendations on the subject. Typical subjects currently being studied: methods of reducing materials handling costs, and methods of reducing rejects.

▶ **Top Management's Role.** After each meeting, the secretary sends minutes of the proceedings to each member of the Senior Board of Directors. The company has found that this is an ideal way to keep members of the board informed of the company's progress and problems since senior board members get together only four times a year. Company directors may attend the Junior Board meetings only on invitation from the lower body.

Success of the plan can be attributed to the Board of Directors who initiated it. To date, they have been more than amenable to the recommendations of the lower body. Directors feel that they must consider seriously any recommendation made by this board since their junior executives are close to the company's problems and since all recommendations must be approved unanimously by the lower board before that body will submit them.



STEEL MILL WORK-ROLL JOURNAL being sprayed with metal to build up worn surfaces at U. S. Steel's homestead works. This shot was taken from the new 16 mm sound, full color motion picture made by the Metallizing Engineering Company, Inc., Long Island City, N. Y., to describe applications of metallizing.

Business Outlook: What's Ahead for 1953?

THE MAIN FORCES supporting the current business boom seem strong enough to carry well over into 1953 according to a report prepared by the McGraw-Hill Department of Economics. In addition, results of the November elections cheered business men in general with the prospect that they will no longer be whipping boys for Washington bureaucrats. In brief, this is the business outlook for 1953:

- Government spending will be stable or slightly higher next year as a result of commitments already made.
- Business plans for capital expenditures (usually a reliable business barometer) are slightly lower for 1953. A special McGraw-Hill survey shows that manufacturing companies will spend substantially less than in 1952. But utility, trade and service industries will take up the slack with increased expenditures.
- Retail trade is on the upswing and output of consumer goods is at its highest since mid-1951. Biggest unknown in the business outlook is how far this upswing will go.
- Present strength in consumer lines is supporting many of the more ambitious plans for capital expenditures. Any drop in consumer spending would be quickly reflected in the sales and profits of industrial companies and would probably cause a revision downward in capital spending plans.
- Hard selling, particularly at the retail level, may be needed to justify continuing good business after mid-1953.

▶ **Government spending.** The defense program is rolling slowly but steadily with a higher volume of equipment scheduled for delivery in 1953 than in 1952. Most observers feel that 1953 will be over before the new administration can change the rate of defense procurement drastically. In addition, state and local spending for such vital projects as highways and schools may increase as much as two billion dollars in the next year.

▶ **Capital spending.** Plans for capital expenditures in the last part of 1953 are very tentative. It appears that spending in the first half of the year will be close to the present rate. There are two forces that might bring about a cut in this type spending: pressure of rising costs on profit margins as a result of a new round of wage increases or competitive price cutting; or a drop in the level of consumer spending.

In general, the biggest companies are keeping up their capital expenditures, smaller companies are cutting down. Most machinery manufacturers plan to spend less in 1953, but there's a great diversity of plans within the same industry.

Here is a breakdown by industries:

Transportation equipment industry plans one of the largest declines, since most aircraft makers (who had the largest expansion programs in the industry) have most of their defense facilities completed.

Steel industry will also show a marked decrease in spending. The tremendous expansion program that boosted capacity from 100,000,000 to 125,000,000 tons will be fairly well completed by the end of 1952.

In durable goods lines, 1953 plans are close to or higher than actual expenditures in 1951. Reason: these are defense-supporting industries in which 1952 expansion projects have some carryover into 1953.

Electrical manufacturers are another exception to the general downtrend. The industry spent considerably less than it planned in 1952 and will try to make up lost time in their expansion programs in 1953.

Oil companies are in the same shape. Their spending plans for new wells, refineries and pipelines fell behind schedule. They'll try to build them in 1953.

Textile manufacturers started cutting back their capital spending in 1952. They'll spend even less in 1953. Overcapacity of the industry and a severe squeeze on profits stands in the way of new equipment plans.

The chemical industry, considered a perpetual growth industry, is planning 13 percent lower expenditures for 1953. Equipment expansion in 1952 was so large that demand for many chemicals will be satisfied even with further growth in the markets. This industry's figures are further pulled down by severe drops in the plans of Rayon producers and companies making industrial chemicals.

Railroads are planning less spending as their freight car expansion and conversion programs to Diesel locomotives near completion.

Many of these plans for increased or decreased spending must be viewed with caution since programs undoubtedly will change during the year. In addition, this survey was made far in advance of the actual expenditure period.

▶ **Consumer spending.** Toughest thing to predict is what the average consumer will do with his money. Figures on pre-Christmas trade may be a tipoff of things to come in 1953. However these facts are sure:

Amount of consumer credit has increased in the past four months by more than 1 billion dollars, one of the most rapid rises on record. Some of this credit buying may continue in 1953, but economists feel that caution about growing debts may slow it down.

Production of consumer goods can be expanded considerably in the first half of 1953. This is particularly true of durable goods, for which more steel will be available. As a result inventories at retail levels could accumulate, and if retailers started price cutting, look for consumers to hold back on purchases and wait for more price reductions.

Capital Expenditures

(Millions of Dollars)

	Actual 1951	Estimated 1952	Estimated 1953	Percent Change 1952–1953
Steel	1,304	1,718	1,428	−17
Machinery	675	773	661	−14
Electrical Machinery	359	407	468	+15
Autos	736	909	791	−13
Transport Equipment	182	229	144	−37
Food	968	933	998	+ 7
Textiles	695	491	417	−15
Petroleum	2,014	2,812	2,967	+ 5
Chemicals	1,283	1,503	1,301	−13
Other Manufacturing	2,914	3,033	2,578	−15
All Manufacturing	11,130	12,808	11,753	− 8

(1951–52 from Department of Commerce)

Moving-Coil Makes Fast-Acting Clutch

USING THE SAME MOVING COIL PRINCIPAL as in the electrodynamic loudspeaker of an ordinary radio receiver, Jacob Rabinow, National Bureau of Standards, has developed a fast response clutch for rapid starting and stopping of equipment such as tape recorders in high speed computers. Direct current applied to a coil located in a magnetic field activates the clutch. The force resulting from the interaction of the coil current and the magnetic field moves the coil and causes the clutch output disk to be pressed against the rotating input members.

Rabinow claims that this clutch is inherently capable of faster response than conventional electrical or magnetic friction clutches. Conventional clutches require time as well as energy to build up a field after the actuating voltage is applied. In the loudspeaker clutch, the necessary magnetic field is in existence before the clutch is actuated.

Compensating coils are used to make the inductance of the moving coil in the new clutch negligible. As a result, the time required for the coil current to build up and press the clutching surfaces together can be made equally negligible.

▶ **Experimental model.** With an experimental model, Rabinow was able to obtain full output-shaft torque of 10 oz-in. in less than a third of a millisecond after application of the actuating voltage. Magnets and coils rotated with the clutch input shaft in this model. And two pairs of slip rings transmitted magnetizing and actuating currents to the rotating assembly.

A thin flexible diaphragm was attached to the actuating coil so that when the voltage is applied, the coil jumps forward and presses the clutch output disk between the rotating diaphragm and a rotating backing disk. Vent holes in the output disk, diaphragm and case promote cooling and prevent compression or rarefaction of air by the diaphragm.

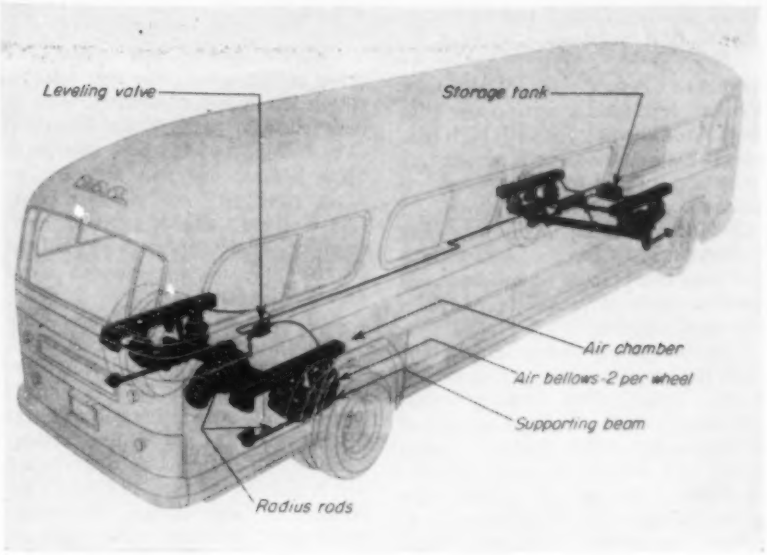
To reduce inductance, the compensating coils were attached to the pole faces of the electromagnet, close to the actuating coil. All the coils are connected in series so that the current is the same in all windings, however the direction of current flow in the compensating coils is opposite to that in the actuating coils. This arrangement cancels out the inductance of the moving coil. In the model, the compensating coils reduce the 1 kc inductance of the actuating coils to 0.15 millihenry from an uncompensated value of 2.4 millihenries.

▶ **Test results.** With 300 volts applied to the electromagnetic field coil and to the moving coil, Rabinow determined that the output shaft began to move in 200 microseconds and reached full speed in 300 microseconds. With 100 volts on the field and 215 volts on the actuating coil the corresponding times were 500 and 625 microseconds.

The actuating voltages required for fastest response are needed only momentarily. They are reduced as soon as the clutch comes up to speed to prevent overheating and burnout. With this model, maximum safe values of current for continuous operation were found to be 0.2 amp for the field coil, and 0.5 amp for the actuating coil. At these maxima, the output torque was measured at 10 oz-in.

Tests indicated that the compensating coils decreased delay times from 900 microseconds to 600 microseconds. Rabinow feels that with the compensating coils, clutch response time is limited by mechanical rather than electrical factors.

Currently NBS is attempting to improve this design with a model in which the actuating means are stationary and operate the clutching mechanism through thrust bearings.



Air Replaces Springs in New Bus Suspension

Compressed air held in eight heavy, flexible air bellows made of rubberized nylon tire fabric replaces conventional leaf springs on new GMC buses. General Motors claims the new suspension means a smoother and safer ride for passengers.

Main advantages claimed for the new system: 1) It responds to even slight vibrations and gives maximum benefits in the range of high frequency vibrations where metal leaf springs fail to flex because of friction between the leaves. 2) It permits a progressive rate of deflection. The more the air is compressed the more its resistance. 3) The new system requires no lubrication because all joints are rubber-bushed. 4) There is no appreciable wear in any part of the system.

Leveling valves meter the compressed air into the system so that, as the coach is loaded, air pressure is increased to compensate for the added weight. As the coach is unloaded, the same valves release air to keep the coach at a fixed level.

The coach air system supplies the compressed air which is metered by the leveling valves into air chambers consisting of a rectangular rubber-lined sheet steel box with large openings into two bellows at each point of axle suspension.

Aircraft-type direct double acting shock absorbers are used on both sides of front and rear axles to control rebound and further cushion the air ride. Rubber-mounted radius rods maintain the positions of each axle against lateral, longitudinal and torsional movement, and need no lubrication.

Low Alloy Steel for High Temperature Work

CRUCIBLE STEEL COMPANY OF AMERICA has developed a ferritic low alloy steel, Crucible 422, for such high temperature applications as high strength bolts and blades for steam and gas turbines.

Principal material in the new alloy is chromium, 13 percent; 422 contains less than one percent nickel, and only small amounts of vanadium, molybdenum and tungsten.

Crucible claims that a ferritic type steel has many advantages over austenitic higher alloy types. Typical advantages: lower thermal coefficient of expansion, better thermal conductivity, and higher damping capacity. In addition the cost of the new alloy is considerably less than that of so called "superalloy" materials. Heat treatment of Crucible 422 permits the obtaining of a wide range of mechanical properties.

This is how the new alloy meets requirements for service above 1,000 F:

- Stress rupture and creep strength are equivalent to those of austenitic steels at 1,000 and 1,100 F.
- It maintains reasonable structural stability.
- It possesses adequate scale resistance.
- It maintains good ductility at service temperature and at room temperature subsequent to a long period of service.
- It has high notched stress-rupture strength at service temperatures.
- Combines room temperature strength and ductility obtainable with heat treatment.

In the Crucible 422 the chromium provides scale resistance, a requirement of any material that must stand exposure to high temperature steam or products of combustion. Molybdenum appears to have a beneficial effect in maintaining toughness. The combination of tungsten, molybdenum and vanadium gives the steel good resistance to tempering.

Can Great Britain Denationalize Steel?

LONDON—Great Britain's Conservative party has discovered that denationalization of an industry is far more difficult than nationalization. Last year's denationalization legislative plans never matured because the death of King George VI upset Parliament's schedule. When the Conservatives attempt in the current session to repeal the 1951 bill that nationalized the steel industry, they face one of the hottest legislative fights in history.

Clement Atlee's Labor Party has already served notice that they will renationalize iron and steel as soon as they return to power if the Conservatives turn it back to free enterprise. Some Britains fear that such an "in-again, out-again" policy would bankrupt England's already tottering economy. So even supporters of free enterprise have become cautious about denationalization.

According to Aubrey Jones, Conservative member of the Parliament writing in the November issue of the American Iron and Steel Institute's *Steelways* Magazine, this is how Great Britain will try to end Nationalization:

Passage of the denationalization bill will terminate the Iron and Steel Corporation of Great Britain, the present government operator of the steel industry. Holdings of the corporation will be transferred to a Holding and Realization Agency who will dispose of the securities to private companies subject to the Treasury's approval.

However, even the Conservatives don't hope to end government control of iron and steel. The bill will also set up an Iron and Steel Board that would have statutory power in its own right. Typical functions of the Board: to check abuses, for example by fixing maximum prices; to stimulate development and expansion of raw material supplies; to serve as a link between industry and the state so that industry's policy's are in accord with national needs.

▶ TINY GLASS BALLOONS, about the size of a grain of sand, appear to be a useful new construction material. Developed by the Armour Research Foundation of the Illinois Institute of Technology, the ceramic bubbles replace sand or other aggregate in the mixing of concrete to produce a fluid mix that can be pumped into forms through rubber hoses. In addition they impart increased strength and improved insulating properties to concrete, mortar, and plaster.

▶ TRITIUM, the three-nuclear-particle isotope of hydrogen, is being used to produce a substantially constant light source for calibrating instruments containing phototubes. The radio active product of the Oak Ridge Nuclear Reactor is combined with stilbene, a crystalline substance, and processed chemically to form a solid crystal. Scientists at Tracer Lab, Inc., report that the tritium constantly emits beta rays which cause the stilbene to fluoresce producing a light of almost constant luminosity. The tritium crystal will retain over 50 percent of its light output for ten years, compared to the six months life of radium activated sources currently being used.

▶ ATOMIC ENERGY COMMISSION has determined that scrap steel contaminated with natural uranium is not injurious and will not provide a technical or health hazard. On the basis of this report, AEC has released 1370 tons of contaminated scrap into normal steel making channels with an impressive savings in transportation and processing costs.

▶ RADIOACTIVE RADIUM-BERYLIUM is being used to measure tissue-paper-thin coatings of silver on radar equipment with an accuracy of 10 millionths of an inch at the Armour Research Foundation. The process which takes about five minutes compared to the three hours formerly required for a destructive test, involves bombarding the silver coating with the radioactive material to form radioactive isotopes of silver. Geiger counters measure the activity from the silver coating to obtain an accurate picture of thickness.

▶ ALL-ELECTRONIC SCANNER developed by Radio Corporation of America may increase the use of full color illustrations in magazines by reducing the cost and time of preparing engraving plates. The instrument provides for rapid, automatic corrections of color separation negatives; scanning a 11 by 14 in. plate in 10 minutes with error limits of plus or minus two percent. RCA's new device consists of a beam splitting arrangement, two cathode ray tubes similar to television picture tubes, a computer, and a conventional camera. Light from the flying spot tube is split into three beams of light to scan three fixed positive. A lens and phototube mounted behind each positive picks up the transmitted light and sends a signal to a computer. The output of the computer is fed to the second cathode ray tube and the image reproduced on this tube is photographed by a conventional camera to turn out the corrected negative. RCA expects to market the device late in 1953.

▶ SPHERICAL SHELL CAMERA developed at Boston University for the U. S. Air Force can photograph 300 square miles at an altitude of 30,000 ft compared to the 70 sq. miles covered by standard mapping cameras of the same focal length. Heart of the camera is a ball-shaped lens which rotates at high speed inside a hollow sphere that rotates at a different speed.

Estimating the Weight of Joints in Cylindrical Vessels

VICTOR TATARINOV
Consulting Engineer, Pilsen, Czechoslovakia

IT IS SOMETIMES NECESSARY to estimate the net change in weight that results from joining together two cylindrical vessels or pipes. For the case shown in Fig 1, the joint area (shaded) is given by:

$$A = 4\frac{h}{r}\int_{x=0.5\pi r}^{x=0} (r^2 - x^2)^{1/2}\,dx = \tfrac{1}{4}\pi^2 hr_1$$

The weight of material that must be added to make the joint can be expressed as:

$W_a = \gamma \times A \times t_1 = \gamma \times f(A) \times r_1^2 \times t_1$ where

γ = density = 0.283 lb/in.³ for steel

t_1 = thickness of smaller cyclinder, in.

r_1 = radius of smaller cyclinder

$f(A)$ = function of area

$= \frac{1}{4}\pi^2 (h/r)(r_1/r_2)$

The weight of material that must be removed from the larger tube is:

$$W_r = \gamma \times f(A_r) \times r_2^2 \times t_2$$

where t_2 = thickness of larger tube, in.,

$$f(A_r) = \frac{8\pi\alpha}{360} \times \frac{r_1}{r_2},$$

r_2 = radius of larger tube, and the other symbols are the same as previously used.

The mean value of α (See Fig. 1) is given by:

$\alpha = 2$ arc sin r_1/r_2. The length of weld, $L = f(L)(r_2)$. The chart, Fig. 2, shows values of $f(A)$, $f(A_r)$ and $f(L)$ for different ratios of the radii r_1 and r_2.

For convenience and more accurate results, the curves for f(A) and f(A_r) are each divided into two sections. As indicated on the graphs, one section refers to the ordinate scale on the left whose range is from 0.01 to 0.2 and the other is used with the scale that ranges from 0.1 to 5 which appears at the right.

Example: Determine the net joint weight for a 10 in. diameter pipe of ¼ in. thickness welded to a 20 in. diameter pipe that is ½ in. thick.

From the chart, at r_1/r_2	= 0.5,	
Line I gives $f(A)$	= 0.168	*(right hand scale)*
Line II gives $f(A_r)$	= 0.825	*(right hand scale)*
Line III gives $f(L)$	= 3.2	*(left hand scale)*

Thus

A	$= (0.168)(0.5 \times 20)^2 = 16.8$ in.²
A_r	$= (0.825)(0.5 \times 20)^2 = 82.5$ in.²
W_a	$= (0.283)(16.8)(0.25) = 1.19$ lbs
W_r	$= 0.283\,(82.5)\,(0.5) = 11.74$ lb
Net weight of joint	$= 11.74 - 1.19 = 10.55$ lb
Length of weld	$= 3.2\,(0.5 \times 20) = 32$ in.

If the end of the smaller pipe were cut at 60, 45 or 30 degrees, these above values must be multiplied by 1.15, 1.41 or 2, respectively.

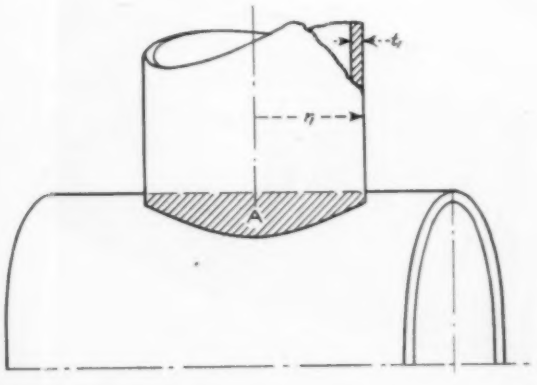
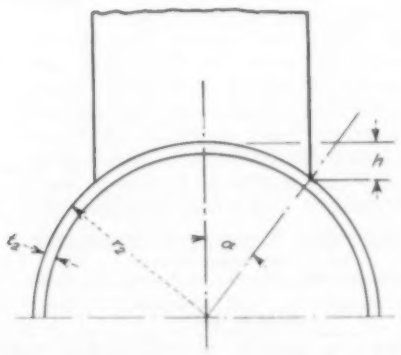


Fig 1



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Estimating the Weight of Joints

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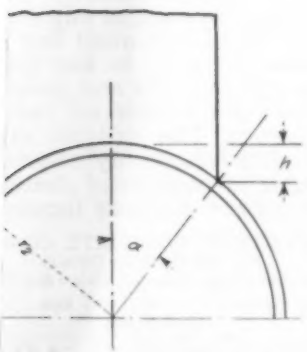

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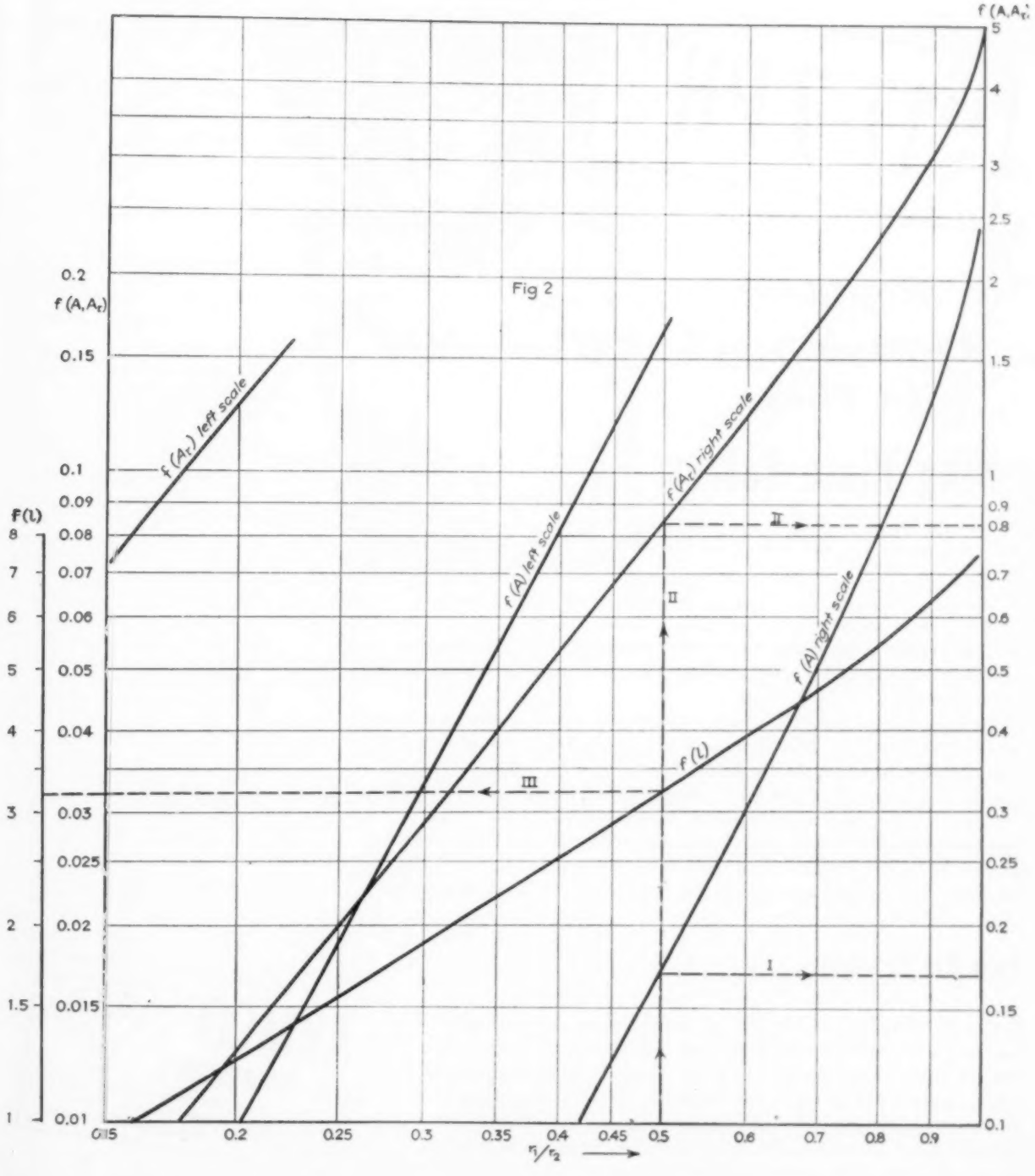
Estimating the Weight of Joints in Cylindrical Vessels (continued)

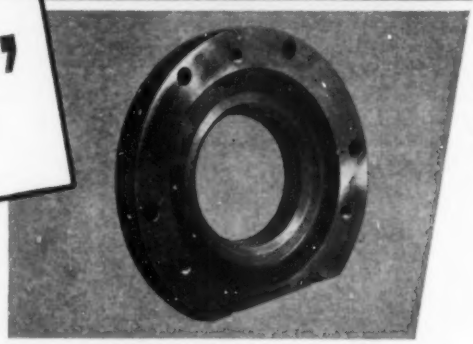


A ring-plate type valv for freon compressor made of Armco 17-7 PH Stainless Steel strip

"17-7 PH"

Replaces Carbon Steel In These

Ring-Plate Valves



Here is how the ring-plate type valve is mounted and held in its retaining plate.

This is the way the simple and efficient ring-plate valves operate in the compressor.

In a well-known line of freon compressors, Armco 17-7 PH Stainless Steel has proved its superiority for ring-plate valves and now replaces the carbon steel formerly used.

For these rings Armco 17-7 PH strip, 0.040-inch thick, is purchased in the cold-worked condition. After blanking, only a single low-temperature heat treatment is required for the desired hardness, since cold-working has already transformed the material. Resulting yield and tensile strengths are very high.

This is another case where physical characteristics and low-temperature heat treatment of this precipitation-hardening stainless steel produce a better product in fewer operations. Line check-valve plates and pump-valve discs are among other related applications that have been found most successful.

Two PH Grades

Armco 17-7 PH is made in sheets, strip, plates, bars and wire. Single and double low-temperature heat treatments are employed in hardening. There is also a special bar and wire grade, Armco 17-4 PH, that requires only a single low-temperature heat treatment. If you need good corrosion resistance and high strength combined with ready workability, investigate these two Armco Precipitation-Hardening Stainless Steels. Just a post card will bring you complete information.

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Using Taylor's Series to Solve Spiral Gear Problems

HAROLD M. DURHAM

DESIGN PROBLEMS sometimes require solving a trigonometric identity. The general procedure, having a given equation with several functions of the same angle, is to reduce the expression to that of a single function and solve. This procedure is not always a simple one since the resulting function often becomes quite complex. In many cases, however, the work can be simplified by using Taylor's Series. For example, consider the following spiral gear design.

Given

Center distance = 5 in.
Ratio = 2 to 1

$$\text{Pitch dia of driver} = \frac{n}{dp\cos\alpha}$$

$$\text{Pitch dia of driven} = \frac{N}{dp\cos\beta} = \frac{N}{dp\sin\alpha}$$

The resulting trigonometric equation, which is usually evaluated graphically or by trial and error is

$$\frac{n}{dp\cos\alpha} + \frac{N}{dp\sin\alpha} = \frac{a}{\cos\alpha} + \frac{b}{\sin\alpha} = \text{Twice center distance} \qquad (1)$$

Since the gear ratio is 2, 20 teeth are chosen for the pinion and 40 for the gear. The equivalent spur gears for 10 dp will have 2 in. and 4 in. pitch diameters. Referring to the pair of rectangular axes in Fig. 1, the ratio line is drawn from the origin with a slope equal to 2:1. Then lines *a* and *b* representing the trial diameters of equivalent spur gears, i. e. 2 in. and 4 in. pd are drawn. By laying off on a separate strip of paper a line, equal in length to twice the center distance of the spiral gears, or 10 in., two locations can be determined where a line of this length will terminate at both axes and pass through the point *p*. These are shown in the figure.

To evaluate solution No. II, the approximate value of angle α_2 is scaled as 31 deg 35 min. Placing numerical values in Eq. (1),

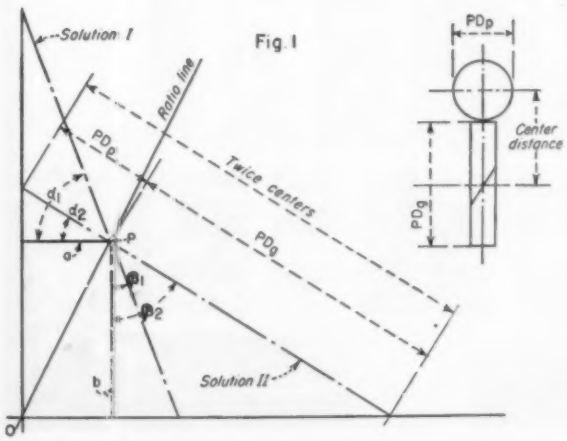


Fig. 1—Graphical method of finding the approximate value of α_2 to be used in Taylor's series for solving a trigonometric identity.

Twice center distance

$$= \frac{2}{\cos(31\text{ deg }35\text{ min})} + \frac{4}{\sin(31\text{ deg }35\text{ min})} = 9.98515\text{ in.}$$

Thus the angle 31 deg 35 min is not quite the correct value. Instead of trying successive new values, near this angle, a Taylor series (see Fig 2), is expanded as follows:

$$f(x) = f(c) + (x-c)f'(c) + \frac{(x-c)^2}{2!}f''(c) + \text{- - - - - - - -}$$

Since $(x - c) = h$,

$$f(x) = f(c) + hf'(c) + \frac{h}{2!}f''(c) \text{ - - - - - - - - - - - - - - - -}$$

Dropping second and higher order terms and solving for h:

$$h = \frac{f(x) - f(c)}{f'(c)}$$

In the example, $f(x) = 10$, $c = \alpha_2$ and $f'(\alpha_2) = \frac{d}{d\alpha_2}(2\sec\alpha_2 + 4\csc\alpha_2)$

$$= 2\sec\alpha_2\tan\alpha_2 - 4\csc\alpha_2\cot\alpha_2 = -10.97912\text{ in.}$$

Therefore, $$h = \frac{10 - 9.98515}{-10.97912} = -.0013.52\text{ radians} = -4.65\text{ min}$$

and $$\alpha_2 = 31\text{ deg }35\text{ min} - 4.65\text{ min} = 31\text{ deg }30.35\text{ min}$$

This value of the angle makes possible the final calculation of pitch diameters for pinion and gear, by substitution in Eq. (1) viz,

$$\frac{2}{\cos 31\text{ deg }30.35\text{ min}} + \frac{4}{\sin 31\text{ deg }30.35\text{ min}} =$$

$$2.3458 + 7.6542 = 10.000\text{ in.}$$

Since the identity is satisfied, the modified value of α_2 is correct. If the identity did not check, the new answer would be used for the second approximation in $f(c)$ and the process repeated until a check is obtained.

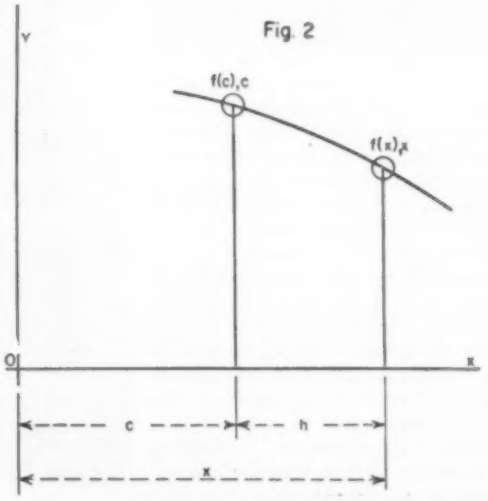


Fig. 2—Interval *h* of Taylor's series is shown as it relates to values $f(c)$ and $f(x)$. In the example, x corresponds to α_2 and c is the approximate value from Fig. 1.

Space Oscillator for Field or Laboratory Testing

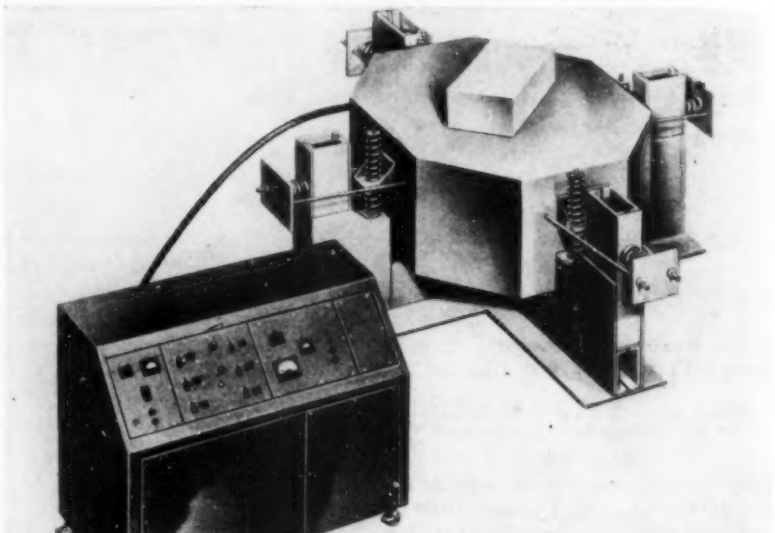
A new space oscillator has been designed to excite one, two, or three directional mechanical vibrations, for fatigue testing of specimens, and for determining the dynamic characteristics of other materials.

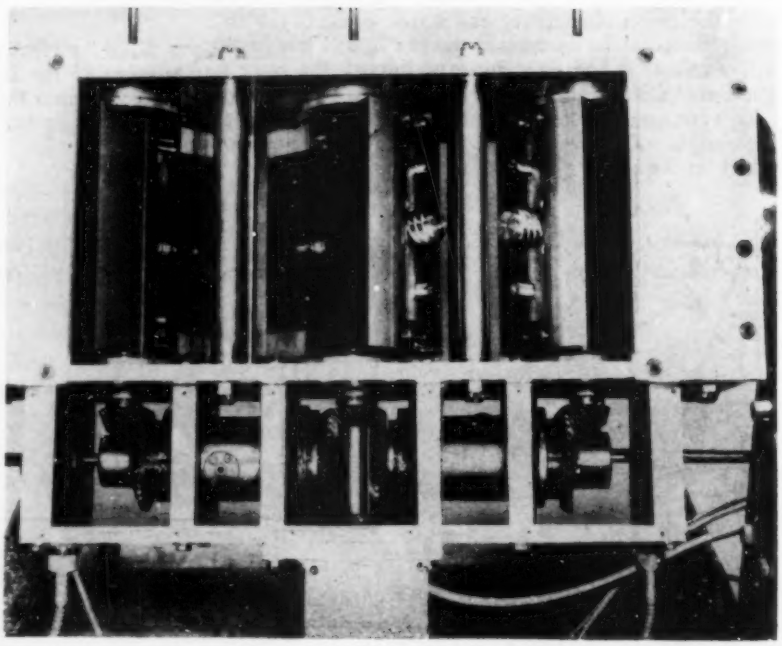
Displacement, velocity and acceleration are continuously variable with respect to magnitude, direction, and action line without interruption of test procedure or repositioning of the specimen. The apparatus produces pulsating forces or moments for the purpose of testing the dynamic characteristics of specimens, instruments, structures, soils, and other materials.

The oscillator consists of a housing which supports three parallel shafts. On each shaft is a set of weights whose center of gravity may be shifted eccentrically, thus producing a centrifugal force. Means are also provided for varying the angular relationship between the centrifugal forces produced by the outside sets of weights with respect to the centrifugal force excited by the central set of weights. Thus, the oscillator actually produces three forces, the resultant of which is determined by the magnitude and direction of the individual forces. The resultant output force of the oscillator is, therefore, controlled and varied by the independent variation of the three component forces. Rotation of the outside shafts is opposite in direction to rotation of the center shaft. Therefore, a linear force may be produced which pulsates from zero to maximum sinusoidally, and in fact, varies from maximum in one direction to maximum in the opposite direction once for each rotational cycle of the shafts.

The oscillator has a rated capacity of 2000 lb. at 15 cps and 1000 lb. at 60 cps, with proportionately smaller forces over the range of 3½ to 15 cycles. Amplitudes varying from zero to ½ in. are obtainable. The illustration at right shows the interior of the oscillator mechanism.

Typical applications are: for testing design changes in aviation; checking the springs or suspension systems, and torsional vibration in automobiles.





Buck Engineering Co., Inc., 39 Marcy, Freehold, New Jersey

MATERIALS - PARTS

SPECIFIED BY PRODUCT ENGINEERS

Flush Diaphragm Pressure Pickup

Said to be one of the smallest instruments of its type ever designed for quantity productions, the new star-type 4-310 pressure pickup has features not only of small size, but also in its negligible temperature sensitivity, its resistance to acceleration effects, and its adaptability to many test conditions and mounting requirements. Its applications range from turbulence investigations in wind-tunnel work to surveys of hydraulic-system pulsations, and pressure-surge patterns in pumps and processing equipment.

Adaptable to both liquid and gaseous fluid-pressure measurements over a temperature range of —65 to 165F, the type 4-310 features a flush diaphragm, which increases its field of application. Due to this design, the instrument can be mounted in aircraft skins, test hulls, and flow lines without causing false turbulence patterns. Since connecting tubes or bypasses need not be used, pressure drops, cavity resonance, and phase errors are eliminated. A variety of mounting methods may be used, and flanges are available to increase the advantages of direct-sensing design.

Measuring only ½ inch in diameter and less than ¾ inch in length, its flush diaphragm is designed for insertion directly into a process vessel, or a stream of either liquid or gas for test monitoring purposes.

Unbonded strain-gage windings connected in a 4-arm bridge are used as the active elements. Either a 10 volt d-c or 10-volt RMS a-c source may be used for bridge excitation. The pickup's output is sufficient to drive sensitive galvanometers directly, in cases of relatively low-frequency pressures fluctuations. When measuring high-frequency fluctuations and transient pressure surges, pickup output can be amplified by a carrier system and then demodulated for recording by galvanometers of high frequency response. If output is to be monitored by meters or oscilloscopes, amplifiers normally used for variable-resistance gages, such as the SR-4, may be used.

Internal features of the 4-310 pressure pickup are shown in the enlarged view, right. The two active arms of the 4-arm bridge are wound around the vertical pins joining the two star-shaped springs. Pressure on the diaphragm, which rests against the ball atop the upper spring, depresses the entire structure. The resultant spreading of the pins stresses, and thus changes the resistance of the two active arms to cause a bridge unbalanced precisely proportional to the pressure. The two inactive bridge arms, wound around the base, are unaffected.

Due to the geometry of the spring-suspension system and arrangement of the windings, acceleration effects, both axial and transverse, have little effect on bridge output, because they are self-cancelling. Temperature compensation for zero drift over a —65 to +165F range is accomplished by a resistance connected in a series with one of the inactive bridge arms.

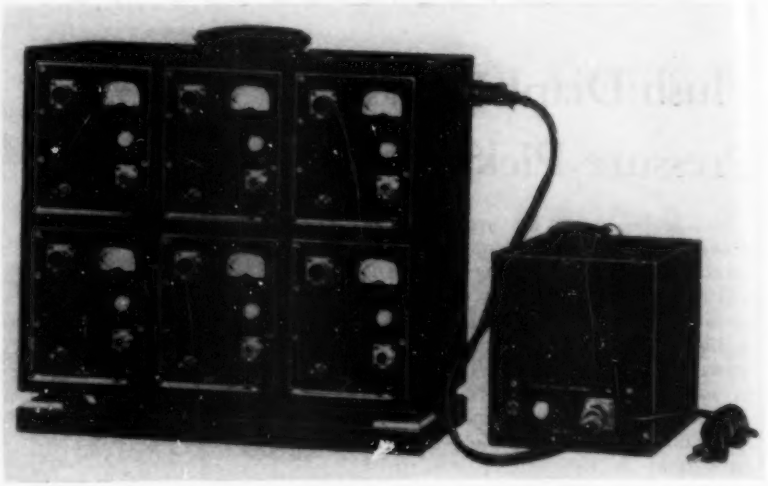
Operating Characteristics

SENSITIVITY: 1:5 mv/v nominal open circuit at full rated pressure. Calibrated sensitivity is furnished with each pickup; EXCITATION; 10 volts d-c or 10 volts a-c (5kc max.); INPUT IMPEDANCE; 350 ohms, ±5 percent; OUTPUT IMPEDANCE; 350 ohms, ±5 percent; PRESSURE RANGE; 5-15-50-150 psig; PRESSURE OVERLOAD LIMIT: 300 percent full scale without damage to strain-gage wires; TEMPERATURE RANGE: —65F. to +165F; ZERO DRIFT; less than 0.04 percent of full-scale per deg. F: SENSITIVITY DRIFT: Less than 0.03 percent of full scale per deg. F; LINEARARITY: Better than 1 percent of full-scale output; HYSTERESIS: Better than 1 percent of full-scale output. ACCELERATION RESPONSE: Static: 0.05 percent of full-scale per "g". Vibratory: less than 0.2 percent full scale per "g" to 2000 cps.

Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif.

CONTINUED ON PAGE 220

Portable Six Channel Amplifier Unit



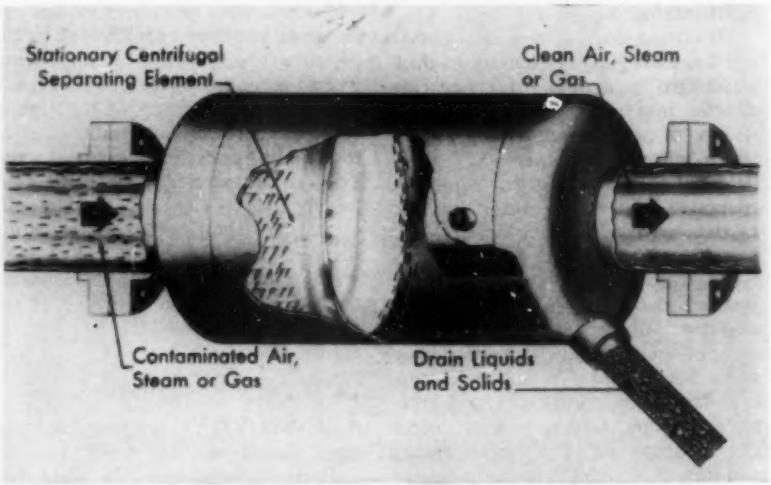
The model 201-A six channel amplifier unit is a portable, (69 pounds complete with power supply), self-contained system used primarily for the accurate measurement of such physical phenomena as strain, pressure, acceleration, vibratory displacement, and velocity.

The model 201-A unit consists of six individually excited, three stage, single channel amplifiers, with output metering and overload indicating circuits, and with linear and integrated amplification used to provide for the use of a wide variety of pickup devices; a separate electronically regulated power supply providing both a-c and d-c power to all channels; a shock mounted cabinet with power plugs for inserting the single channel amplifier units; and the necessary power and test cable assemblies. Recording of the amplifier output is usually accomplished by a tape recording device, or similar recording instruments.

POWER LINE REQUIREMENTS: voltage, 115 ± 15 v; frequency, 60 to 400 cycles per second; INPUT: voltage, 250 microvolts to 0.25 v; impedance 100K ohms, one side grounded; OUTPUT: voltage 1.2 volts rms maximum undistorted; Impedance, maximum output load should be 250K ohms shunted by 100 micromicrofarads; connector type AN3102-14S-2S; AMPLIFICATION: 4000; FREQUENCY RESPONSE: flat within, 0.5 db from 10 cps to 50 cps, 0.1 db from 50 cps to 10 kc, 0.5 db from 10 kc to 15 kc, 2.0 db from 15 kc to 30 kc, POWER SUPPLY OUTPUT: 300 v d-c regulated to ±1 percent; TEMPERATURE: 15 to 130 F (ambient).

The Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio

High Efficiency Line Type Purifier


Stationary Centrifugal Separating Element
Clean Air, Steam or Gas
Contaminated Air, Steam or Gas
Drain Liquids and Solids

Steam, air, gas and vapor lines are cleaned up by line type purifier which is said to combine increased separating efficiency with a more simplified design. This purifier operates automatically and without any moving parts or baffle plates, removing almost 100 percent of all dirt, oil, and moisture even at extreme velocities and pressures.

The impurities are removed through a new stationary centrifugal separating element. The rotational action throws all solids and water outward to the walls of the purifier. Here it is ejected out the drain. The entire action occurs without any appreciable drop in pressure, and the greater the velocity through the unit the better the separating efficiency.

A few of the applications for this unit are: to remove moisture, oil and dirt from gas lines between and after compressor stages, to protect steam ejectors, valves and other pipeline equipment, to remove impurities in exhaust steam and vapor applications which attach surfaces when vented to the air, and to clean up exhaust steam.

This line type purifier is made in all standard sizes up to 24 in. for pressures up to 600 PSIG.

V. D. Anderson Company, 1935 W. 96th St., Cleveland 2, Ohio

CONTINUED ON PAGE 222

When a high-strength steel is needed

for severe cold-formed shapes like these bumpers

Specify→ N-A-X HIGH-TENSILE STEEL

and get all of the requirements of SAE 950

When a material meeting the requirements of the high-strength, corrosion-resisting steels of SAE Specification 950 is used for severe cold-formed shapes, it will pay to investigate N-A-X HIGH-TENSILE steel—the low alloy steel with *built-in formability*. Its finer grain and higher hardness also result in brighter luster when ground and polished for plated parts.

GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division
Ecorse, Detroit 29, Mich.

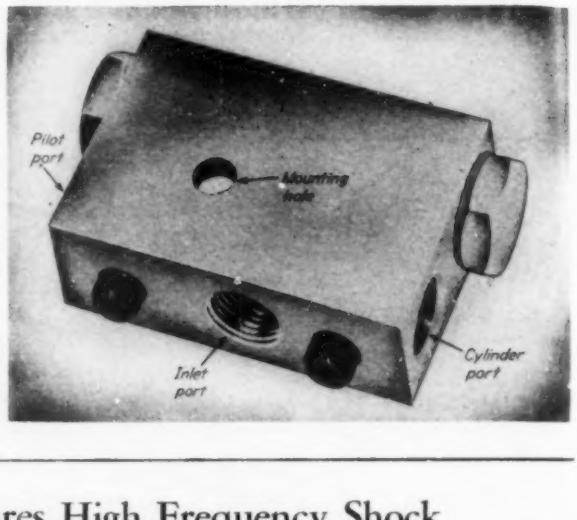
NATIONAL STEEL CORPORATION

Hydraulic Leak-Proof Check Valve

A new pilot check valve, available in $\frac{1}{4}$ and $\frac{3}{8}$ in. pipe size, may be used to lock a cylinder, or part of a circuit without leakage. They are used on hydraulic clamping devices, where a slight leakage would cause loss of the clamping pressure. The pilot check valves have a steel ball for a check, and are generally used with a control valve which will not hold pressure without leakage.

The pilot piston has an area of four times the check valve seat. This ratio of area reduces the pressure required at the pilot port to unseat the check, and insures that unseating will occur even when the locked pressure exceeds the relief pressure setting of the system. Travel of the piston is limited by a shoulder in the body, keeping stresses in the piston to the minimum required to unseat the check. Action of the piston is dampened by the restriction in the pilot port to prevent impact and destruction of parts.

Fluid Controls, Inc., Mentor, Ohio



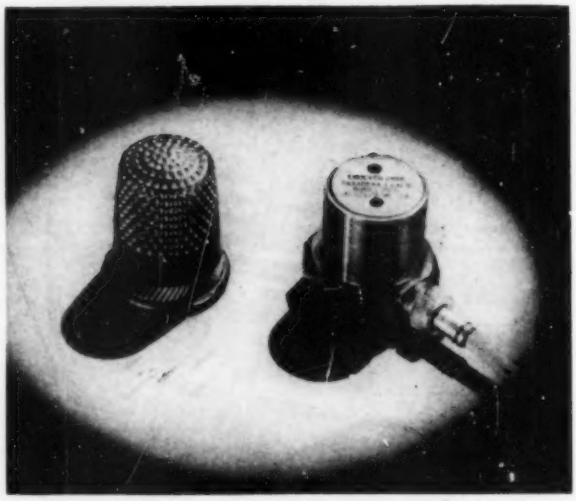
Small Accelerometer Measures High Frequency Shock

A new thimble-size accelerometer is said to provide an improved research instrument for the measurement of high frequency shock and vibration, because its small size and weight permits the testing of small components under actual or simulated shock and vibration conditions. The small size and large output permits its use for missile, aircraft and vibration table measurements.

The instrument gives a self generated output of 5 millivolts per G. The output is flat ±5 percent over the range from 5 CPS to 5000 CPS. And is stable to within 5 percent over a temperature range of —20 C to 70 C. The design is available in models 2201, 2202 and 2203, with model 2201 a general purpose, stainless steel version with a weight of 0.5 ounces and output of 5 millivolts per G. The model 2202 is a special, light weight unit weighing 0.3 ounces. The model 2203 is a large output unit generating 10 millivolts per G.

Associated equipment such as special mini-noise cables, cathode followers and power supplies are available.

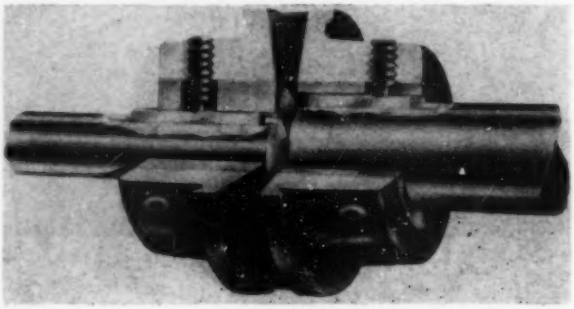
Endevco Corp., 180 E. California, Pasadena 1, Calif.



Flexible Coupling for Applications up to 10 HP.

Cast iron bushed types flexible couplings have been developed for applications up to 10 hp and offer as many as 210 possible bore combinations for each type. In each of the new couplings, two cast iron hubs are joined by a bonded rubber section. The new couplings are to be available in three bore sizes for use with interchangeable bushings. The smallest has a one in. bore and offers 21 possible bore combinations. With the larger $1\frac{1}{4}$ in. bore and $2\frac{9}{16}$ in. bore flexible coupling there are 136 and 210 possible bore combinations. The $1\frac{1}{8}$ in. bore coupling, known as the model FXB75 is already in production.

Maurey Mfg. Corp., 2907 S. Wabash Ave., Chicago 16, Ill.



CONTINUED ON PAGE 224

Portable Temperature Controller

The precision control of a new portable temperature controller is accomplished by plugging the new instrument into a wall outlet and plugging the unit to be controlled into the instrument. Then, by inserting the instrument thermocouple into an oven, bath, thermocouple well, or other device, the true temperature will be indicated by the upper pointer and may be controlled at any desired point by setting the lower pointer to the correct scale position by means of the external setting knob. Two power outlets provide versatility to the instrument by allowing it to control not only temperature but other factors, blowers, fans, and agitators as well. Thermocouple break protection is provided, protecting the thermal system from overheating if a thermocouple should burn out or break for any cause. All models have a dual scale range of 50 to 500 F, iron-constantan, and 0 to 2000F, chromel-alumel, with a selector switch to operate the instrument on one range or the other. Two six-foot thermocouples, one iron-constantan and the other chromel-alumel, are standard equipment with this portable controller.

This portable controller is available in three different models. The model JE is the "on-off" type controller; the model JEP uses the same proportioning type control as in the standard proportioning controller made by this company; and the model JEL is a combination instrument serving either as a high limit controller or an "on-off" type of controller.

All three models have the basic features of this line of precision instruments. Magnetic amplification replaces the usual vacuum tubes, eliminating service interruption due to tube failure, and assuring instantaneous starting. Two pilot lights indicate whether the instrument is heating or cooling the controlled unit. The telephone type relay of the instrument is supplemented by an integral contactor of 1700 watt capacity, permitting the use of these instruments directly on most load circuits without an external contactor.

Taco West Corp., 525 N. Noble St., Chicago 22, Ill.

High Capacity, All Steel Pillow Blocks

A new line of all-steel pillow blocks, having high load-carrying capacity in a compact package, has high radial thrust capacities and the ability to take heavy shock loads, while being provided with minimum dimensions and less than the usual weight.

The bearings are fully self-aligning with a spherical outer race. They are available in both expansion and non-expansion types, and have the adapter type mounting used on other bearings made by this company.

Double piston ring seals keep the lubricant in and dirt and dust out of the bearing mechanism. The bearings are sealed both on and off the shaft, and will be provided in shaft sizes from $2\frac{1}{16}$ to 10 inches.

These new all-steel pillow blocks are fully assembled, permanently adjusted and lubricated and sealed when manufactured. They are shipped ready to install, and will find applications in steel mills, mines, lumbering and oil fields, for crushers, heavy conveyors and similar heavy duty machinery.

In addition to this line of all-steel pillow blocks, this company also manufactures a line of torque arm speed reducers which mount directly on the driven shafts and are locked to them at both sides of the reducers. Output speeds range from 115 to 330 rpm and capacities to 27 hp.

Dodge Mfg. Corp., Mishawaka, Ind.

CONTINUED ON PAGE 226

Temperature Transmitter Adapted to Many Uses

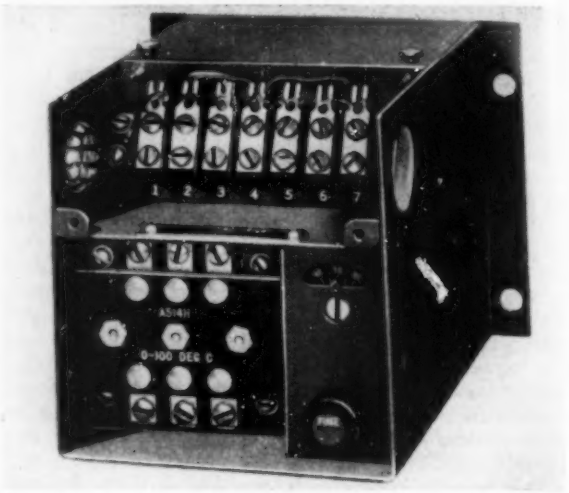
Known as the type T2T autronic temperature transmitter, a new temperature transmitter has been developed for use in chemical and food processing plants, refineries, petrochemical plants, central stations, and can be adapted to many special operations.

The transmitter consists essentially of two major assemblies: The resistance thermometer element, and the thermometer adapter unit. The thermometer element is made of pure platinum wire wound on a ceramic core and sealed in an inconel tube.

The thermometer adapter unit converts resistance changes in the thermometer element to a proportional signal voltage which varies from 0.000 to 0.500 volts 60 cycle a-c for the full range of the measuring element. The thermometer element is connected to adapter unit by a three-wire system that compensates for variations in lead wire resistance with ambient temperature change. A special adjustment is provided in the adapter unit to compensate for minor variations in thermometer element resistance.

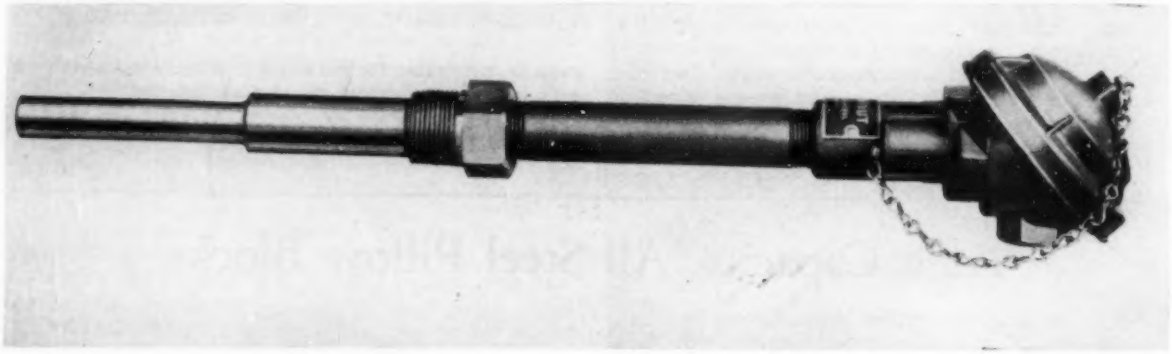
The thermometer adapter unit features a removable range card giving fourteen 50 C spans from —50 to 325 C; six 100 C spans from —50 to 300 C; three 200 C spans from —100 to 300 C; or one 300 C span from —50 to 250 C.

In the illustrations shown, the tubular device is the resistance thermometer element. The other device is the



thermometer adapter unit, with the rear junction box cover removed. Shown are the terminal block, the compensator adjustment, and the interchangeable range card.

Swartout Co., 18511 *Euclid Ave., Cleveland*, 13, *Ohio.*



Rheostat Operates Under Adverse Conditions

The new version of the type A-25, 25 watt rheostat is built to operate under adverse conditions, and is different from the type AM units made by this company because of the added safety factor given by the use of high temperature gray enamel. It is also said to have smoother mechanical operation.

The terminals are made of a mechanically strong, corrosion resistant alloy, and are permanently welded to the winding form. The wire wound on a toroidal ceramic form, and the wire to the terminal is bonded to eliminate poor connections.

The wound ring is made an integral part of the refractory base by vitreous enamel. The actuating arm, made of phosphor bronze, to which is attached a graphite brush, gives good action and electrical control. The shafts are insulated from all live parts by means of a strong shaft insulator. These units are equipped with three terminals to permit either potentiometer or rheostat use.

Specifications: diameter of base, $1\frac{9}{16}$ in.; depth behind panel, $1\frac{11}{32}$ in.; shaft, $\frac{1}{4}$ in. dia., projecting $\frac{1}{2}$ in. beyond bushing; total length of rheostat is $2\frac{1}{4}$ in.; standard bushing, will take panels up to $\frac{3}{16}$ in.; shaft rotation, 285 deg.; terminals, tinned lug type. A special washer is supplied for the non-turn feature.

Hardwicke, Hindel Inc., Newark 5, *N. J.*

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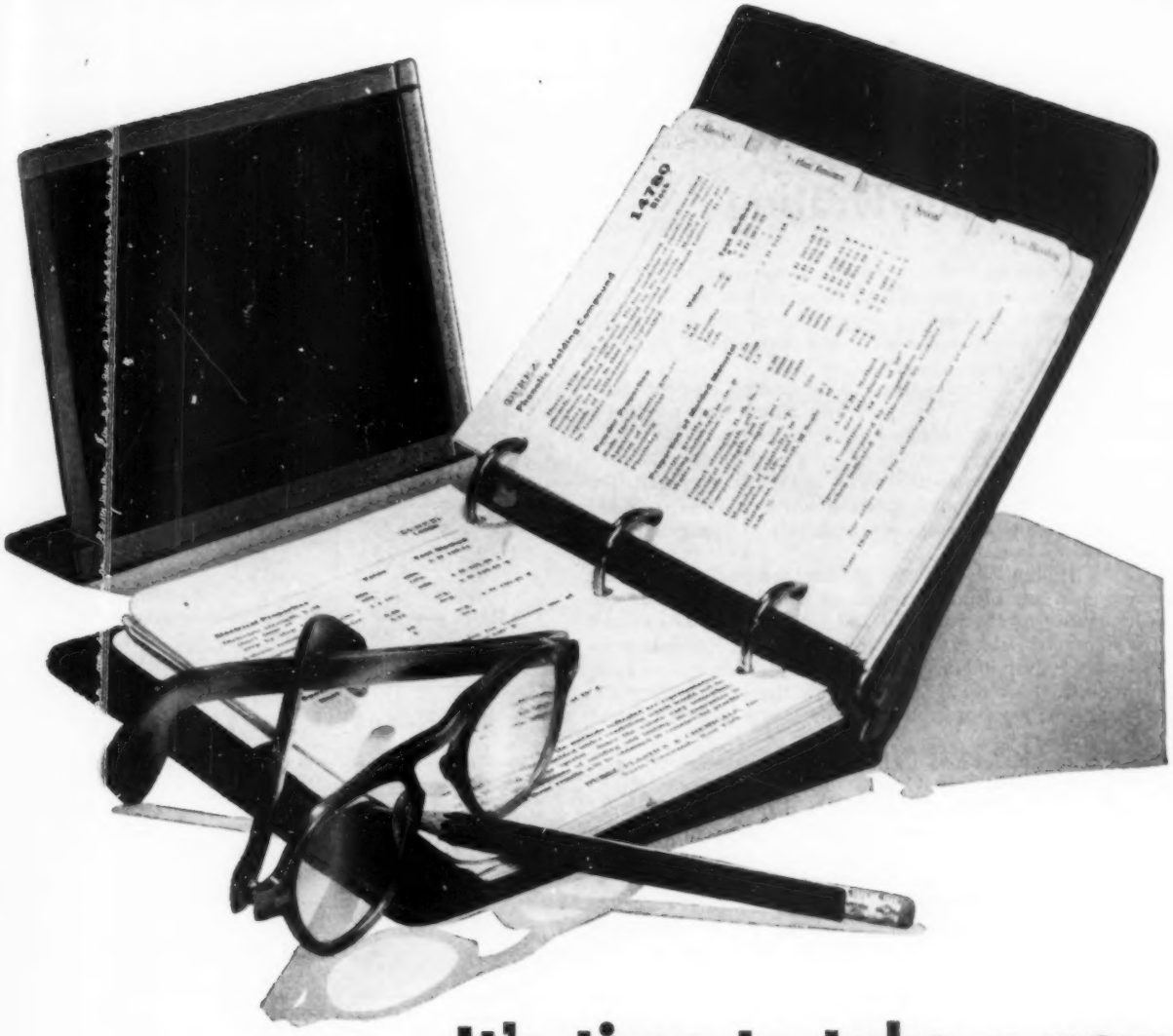

It's time to take a new look at the "working" plastics

The list of materials you could profitably use for a given product or part six months ago may be obsolete now.

In the field of phenolic plastics alone, recent Durez developments can offer you savings in production and assembly costs, improved product service, and greater salability.

A re-survey of the materials picture will show you, for example, that parts to be *metal plated* can now be molded from a new Durez phenolic having excellent physical properties. If you never used plastics because the service your products undergo is "too rough," we have another new material with impact strength as high as 20 foot-pounds per inch (Izod). This is more than double the impact you could get heretofore.

Perhaps you manufacture electrical devices using silver contacts? We have a new phenolic that eliminates the problem of contact corrosion.

These and other results of our continuing plastics research can be utilized conveniently. Custom molders of Durez can serve you from the rough-drawing stage on in... can deliver finished moldings that meet your most exacting tests.

Our field technicians are at your service. Just write.

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MOLDING COMPOUNDS
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DUREZ PLASTICS & CHEMICALS, INC.
2012 Walck Road, North Tonawanda, N. Y.

PHENOLIC PLASTICS THAT FIT THE JOB

Printed Circuit Method Of Radiant Heating

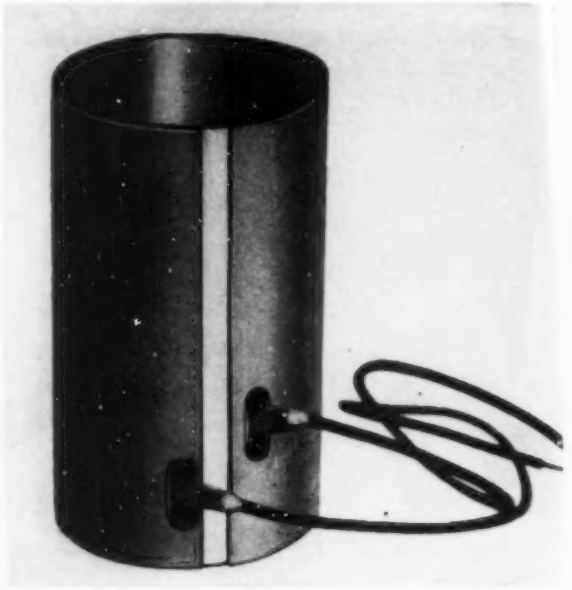
The application of printed circuit techniques to electric heating is said to give many advantages where uniform heat, comparatively low surface temperature of the heating element, low infra-red radiation, and high energy exchange are required.

Known as thermflex, the radiant heating elements have flexibility of design, and can heat almost any surface or contour uniformly. Heating elements may be permanently bonded to any type of phenolic, glass, ceramic, asbestos paper, glass cloth, insulated metal and many other materials. The heater element insulation will withstand twice the rated heater voltage between the terminals and any adjacent conducting surface.

All applications are custom designed and can be furnished in any surface temperature and wattage within the limitations of the base and and insulating materials; and with voltage ratings to 250 volts a-c or d-c. Insulation resistance is over 500 megohms between the terminals and any conducting surface in contact with the heating element. One of the types of heaters already in use is shown in the illustration.

Typical applications include aircraft instruments, cameras and meters; crystal ovens; de-icers; electronic equipment, food warmers; ironers; medical therapy equipment; medicinal vaporizers; photographic equipment; radiant heating panels; recording instruments; unit heaters and water heaters. Tolerance on wattage rating is maintained at ± 10 percent in standard production; however, closer tolerances can be supplied.

Typical max. wattage ratings for base materials are:



Material	Watts Psi	Approx. Temperature (F)
Phenolic (heat resistant)	1.5	200
Phenolic (laminated with metal)	2.2	300
Ceramics	5.0	400
Metals with heat resistant varnish	2.2	300
Phenolics and other plastics	1.5	160

One of the many types of heaters already in use is illustrated.

Thermflex Div., Radio Ceramics Corp., 109 So. Superior St., Angola, Ind.

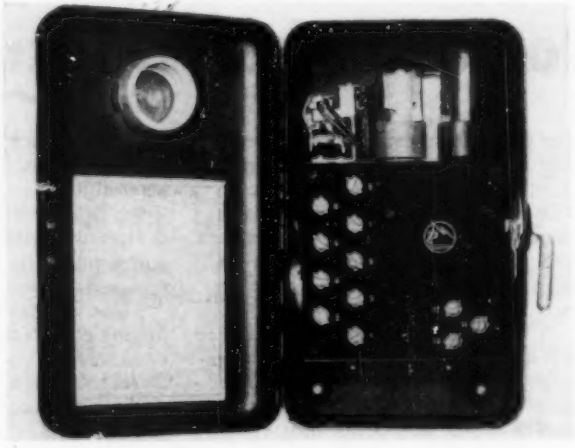
General Purpose Industrial Photoelectric Control

Photoelectric sets for high-speed controls, designed for general industrial and machinery application, are recommended for such applications as counting, conveyor control, short-range signal systems, production inspection, machinery safeguards, and for specialized industrial processes.

Series 20 and 21 controls are adaptable to a variety of industrial applications. The phototube which must be located at the point of observation is available either integral with the housing or in a small separate housing. The latter permits the use of the control where space is limited. A tamper-proof sensitivity adjustment permits positive operation over distances between phototube and light source. A single set of terminal board connections in the control provides the voltage for the light source, which requires only low voltage wiring.

These controls will withstand the high temperature and humidity in industrial applications. Hermetically-sealed, oil-filled capacitors and high-wattage resistors are used.

SPECIFICATIONS: Supply, 115 or 230 v, 50/60 cycles. Designed for high speed operations. Relay operates in 1/20th of a second; Operating Range, 20 feet max; Sensitivity Adjustment, Provides for relay operation at any predetermined level of illumination within range of



10 to 50 foot candles; Relay, Double-pole, single throw; Contact Rating, 20 amps, 115 v a-c, 10 amps, 230 a-c.

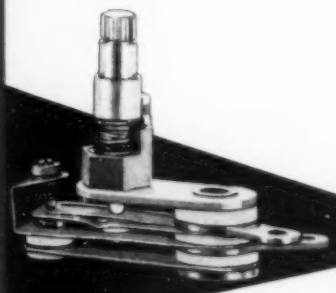
Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

CONTINUED ON PAGE 230

If this is your product

this is your thermostat

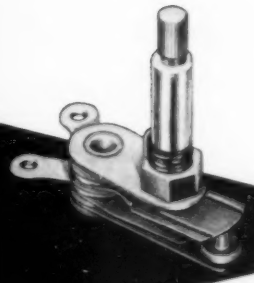
PERCOLATORS
FLAT IRONS
VAPORIZERS
FURNACE FANS
STEAM IRONS
STERILIZERS



TYPE SA THERMOSTATS

for sensitive, snap-action control characteristics. Operate on differentials as narrow as 10° F or on wide differentials up to 100° F. Available in adjustable *(shown)*, non-adjustable or manual reset (Type SM) styles. Also for single-pole double-throw operation.

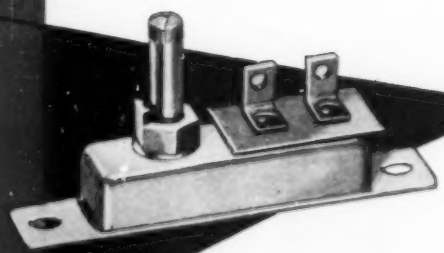
FLAT IRONS
IRONERS
WAFFLE IRONS
PERCOLATORS
INDUSTRIAL APPLIANCES



TYPE S THERMOSTATS

give clean, positive make and break. Single-stud mounting gives metal-to-metal contact with controlled device for faster bimetal response, closer temperature control. Available in adjustable *(shown)* and non-adjustable styles. Interchangeable with Type SA.

BUTTER WARMERS
RECTIFIER FANS
ELECTRONIC DEVICES
INDUSTRIAL APPARATUS
AVIONIC DEVICES
WATER TANKS



TYPE W THERMOSTATS

give snap-action make or break on temperature increase. They closely follow temperature of controlled device, respond rapidly to temperature changes, give sensitive, precise control of high-wattage heater loads, do not interfere with radio reception.

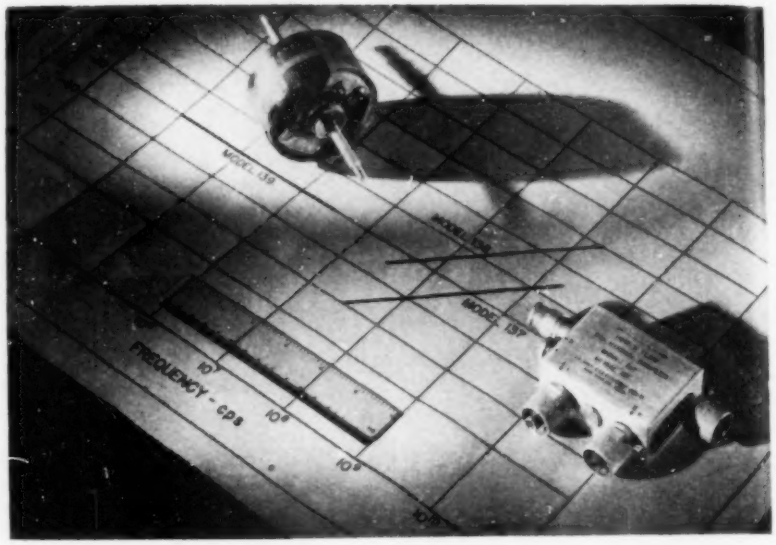
Appliances . . . radar . . . processing apparatus—if your product requires snap or positive-action temperature control, better get in touch with Stevens first. For Stevens application engineers are solving problems like yours every day.

And since Stevens makes the largest line of bimetal thermostats in the industry, there's a good chance that a standard Stevens thermostat will solve your special problem. This means a better break on price and delivery—and at the same time insures the performance and life of your product.

A-6101

STEVENS **manufacturing company, inc.** MANSFIELD, OHIO

Wideband Directional Couplers



Used for measuring numerous parameters relating to transmission lines, wideband directional couplers are available in three models, 137 and 138 for the frequency range 30 to 1500 mc, and 139 for the frequency range 10 kc to 1 mc.

Operating characteristics are shown in the illustration.

By the use of these couplers, with additional instrumentation, the reflection coefficient can be determined directly. This permits the simplification of several important transmission-line measurements: (1) With a continuously-displayed indication of reflection coefficient, load-matching is made rapid and simple since the effect of adjustments can be seen immediately; (2) Load impedance can be measured in terms of characteristic line impedance and reflection coefficient with the result that any impedance can be accurately measured; (3) Magnitude of power delivered to a specific load can be measured regardless of the length of intervening line and the degree of mismatch between line and load.

As the response curves show, the model 137 operates over the entire frequency range from 30 to 1500 mc, with a sensitivity rising from —70 to —35 db. The model 138 covers the same frequency range but has a sensitivity ranging from —55 to —20 db. Operating in a 51.5-ohm coaxial line, these couplers are usable from 0.1 watts up. Reflection coefficient is indicated with an error no greater than 0.02 while directivity over the range is greater than 46 db. Models 137 and 138 have standard coaxial-line fittings.

Frequency independent at a sensitivity of —50 db over the 30-kc to 1-mc range, the model 139 coupler is applied to balanced two-wire lines at power levels ranging up to 15 kw. Directivity and sensitivity are constant from 10 kc to 1mc. Based on a series element consisting of a wideband ferrite-core toroidal current transformer and a specially-compensated capacitor shunt element, the entire coupler is cast in plastic with primary line carried through the axis in the form of a ¼-in.-diameter conductor.

Sierra Electronic Corp.,
830 Brittan Ave., San Carlos, Calif.

Speed Reducer Mounted in Three Positions

A new stock speed reducer, designed to give greater flexibility of use, can be mounted in any of three positions: output shaft horizontal above input shaft, output shaft horizontal below input shaft, or output shaft vertical. Top and bottom surfaces of the housing are machined so that either may be used as a mounting base. For use with output shaft vertical, common angle iron brackets can be furnished.

The input shaft and worm are integral, alloy steel, hardened, ground and polished, with the output shaft of high carbon steel, ground, and the worm gear of high grade bronze. Both shafts are mounted in Timken bearings.

The new model will be available in 9 different ratios. It is known as model 3L2, having a dimension of 3.250 in. from center of worm shaft to center of gear shaft. Varying with the ratio, the horsepower capacity will range between 3 hp down to ½ hp.

Eberhardt-Denver Co.,
1408 W. Colfax Ave., Denver 4, Colo.

CONTINUED ON PAGE 232

This is a locomotive gas turbine mid-frame. As a fabrication it consisted of a number of steel castings and rolled plate components.

Conversion to the rather intricate steel casting called for considerable ingenuity; also close cooperation between the engineering department and steel foundry.

In addition to reducing the cost 50%, redesign to a steel casting (1) resulted in a far superior product (2) cut production time two-thirds (3) substantially reduced the weight of completed structure (fabricated mid-frame shown is not completed to the same point as the steel casting) and (4) improved appearance.

* * *

Here is another example of the engineering teamwork in design and redesign of parts which is resulting in lower costs and improved serviceability with steel castings.

This service is offered without cost or obligation. It makes available through your foundry engineer the full results of the development and research program carried on by the Steel Founders' Society of America.

Keep The Scrap Coming Back . . .

There is a continuing need for steel scrap. Your company can help maintain the high production of all metal products by getting your scrap into the hands of your scrap dealer. Will you do what you can to help . . . now?

STEEL FOUNDERS' SOCIETY OF AMERICA

920 Midland Building — Cleveland 15, Ohio

Design and Build With Steel Castings

Wide Range Traction Dynamometer

Known as the model EL, a new traction dynamometer can be made to operate electrical warning signals, relays, motors, switches, and other devices, and can be set for any loading point between zero and 100,000 pounds.

The blue hand provided on the dial is adjustable to any load desired. This holds one of the contacts. As load is imposed, the white pointer moves forward until it reaches the desired point, closing contact with the blue hand.

The lead wires shown in the illustration may be connected directly to a power source and then to the object to be controlled. A few typical uses for this instrument are in automatic batching machines, warning signals to prevent overloading of cranes or hoists, static load testing of aircraft assemblies and remote indication of loads.

The dynamometer does not depend upon springs, but works upon the principle of deflecting a calibrated beam. It is not affected by quite extreme temperature changes.

Other specifications are: 13 different capacities from 0—500 lb up to 0—100,000 lb; overload protected; red max. hand; rust and moisture proof; weight, 8½ pounds.

W. C. Dillon & Co., Inc., 1421 *S. Circle Ave., Forest Park, Ill.*

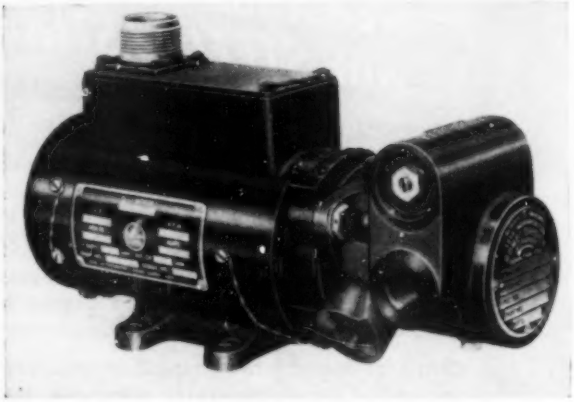
Vane Type Combustion Heater Fuel Pump

A continuous duty electric-driven fuel pump that feeds fuel to aircraft heating and de-icer systems, has a rated capacity of 35 gallons per hour at 25 psi discharge with 20 in Hg absolute inlet pressure.

The combustion heater fuel pump, model RG 9540, is a positive displacement non-pulsating, rotary vane type. It is equipped with an adjustable, balanced type, relief valve which maintains uniform discharge pressure from sea level to 40,000 feet. A by-pass valve is also included in the pump. It is designed for use with straight aviation gasoline and high aromatic blends, and operates efficiently in a temperature range of from —65 F to 180 F. The seal between the pump and motor is leak-proof and flexible through the full temperature range of operation.

The motor is 0.06 hp. 27 V, d-c continuous duty, compound wound, 3.5 amp, explosion resistant with fan cooling, and drives the pump directly at 3700 rpm. A radio interference filter is also built in.

The unit weighs 3.4 lb. and is approximately 7⅓ in. long. The inlet and outlet ports are tapped $\frac{7}{16}$-20 NF-3 straight threads, which is also the size of the seal drain boss. Electrical power is connected through an AN3102 electrical receptable which is attached to the motor.



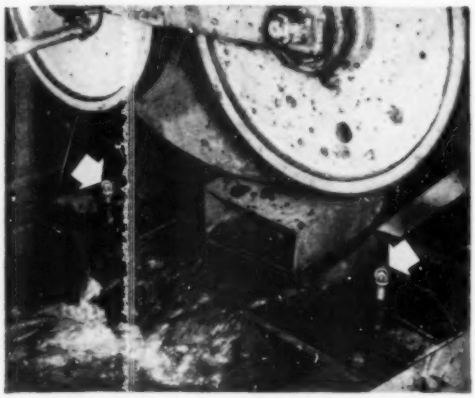
Lear, Inc., Romec Division, Elyria, Ohio

A NEW JET BLACK FINISH for iron and steel, said to have ten times the corrosion resistance of conventional blacks, is used in a water solution at low temperatures. Parts to be treated are immersed for 15 to 30 min in the processing bath, then are rinsed and dried. After oiling or waxing, the black finish is ready for service. The processing bath is non-caustic, and easy to build and control. Operating temperatures are low, and any part which can be immersed in the tank can be treated. It is entirely suitable for machined or threaded parts. Parker Rust Proof Co., Detroit 11, Michigan.

TWO NEW SELENIUM DIODES, types 1S1 and 5U1 have been added to a line of sub-miniature diodes designed for operation in the range of 50 to 100 C. Type 1S1 is rated for a maximum input of 26 V rms at 100 micro amp output; type 5U1 is rated for 130 v maximum at 1.5 milliamperes. The units are set in thermo-setting plastic. Type 1S1 is 0.10 in. wide by 0.21 in. long; type 5U1 measures 0.30 in. wide by 0.25 in. long. The units are encapsulated in a thermosetting plastic. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

CONTINUED ON PAGE 234

12 months "Snorkel" duty... and still in excellent condition



↑ Relubrication fittings for Fafnir Pillow Blocks are indicated by arrows. Once-a-week lubrication plus Fafnir Mechathi-Seals protect submerged bearings.

↓ Complete installation shows relubrication fitting, pipe and Fafnir Pillow Block.

Standard Fafnir Ball Bearing Pillow Blocks

On a conveyor used for lifting steel balls from the water quench bath of a rotary type furnace are two 1½" Fafnir LAK Type Ball Bearing Pillow Blocks. These bearing units, running at 2-3 r.p.m., are three feet under water. The water bath has a pH of about 6 and a temperature automatically controlled at 90°F.

After 12 months of operation at 16 hours a day, 6 days a week, the pillow blocks were removed for inspection. Their condition is shown in the unretouched photograph below. According to a maintenance report, both the pillow blocks and bearings were in excellent condition and suitable for further service.

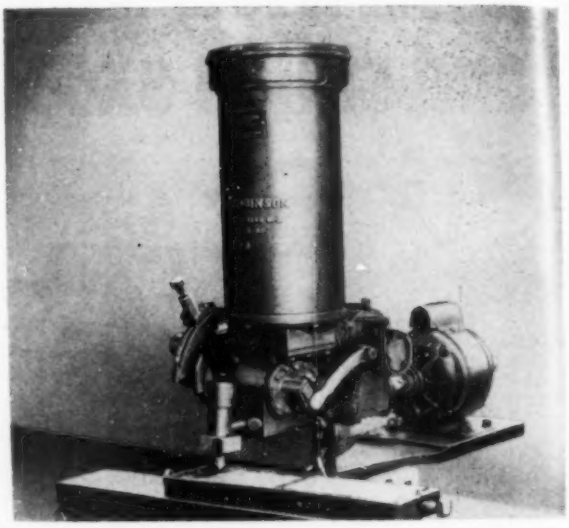
This application may help you to find a better, cheaper way to use bearings. Although it's unusual . . . it serves to demonstrate the multiple-uses of Standard Fafnir Ball Bearing Units plus their ability to operate efficiently under extreme conditions. Whatever your bearing problem, a few minutes spent with a Fafnir representative may help you solve it as successfully. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Unretouched photograph of Fafnir Pillow Blocks, one disassembled, shows condition after 12 months operation 3 feet under water.

Accurate, Positive Gear Metering Pump



The metering pump shown is not a gravity dispenser. It is a positive gear pump that ejects fluid compounds with an accuracy of 3 percent at a rate of 88 ejections per minute by means of a single revolution clutch controlled by an insulated clutch lever. The discharge can be changed in less than two seconds.

The amount of fluid that is metered during a clutch depression is determined by the setting of the cam, shown at the left of the pump. As the crank arm moves to the right, the pawl moves over the teeth of the ratchet until the cam follower on the pawl rides up on the cam and lifts the pawl out of contact with the ratchet. On the return stroke the follower rides to the end of the cam and then lets the pawl lock into the ratchet teeth to rotate both the ratchet and the pump gears for the remaining distance, thereby forcing the liquid through the nozzle. By positioning the cam about the circumference of the ratchet, the rotation of the gear pump can be controlled. A spring loaded detent pin in the selector locks the cam in any one of the index positions of the selector. In order to change the cam settings, and the discharge, the detent pin is lifted from one index position and locked in another. Changing the cam setting can be done while the pump is in operation. No tools are required.

The time for one pump ejection is $\frac{2}{3}$ second. If the clutch lever is kept depressed, the pump will meter at the rate of 88 ejections per minute.

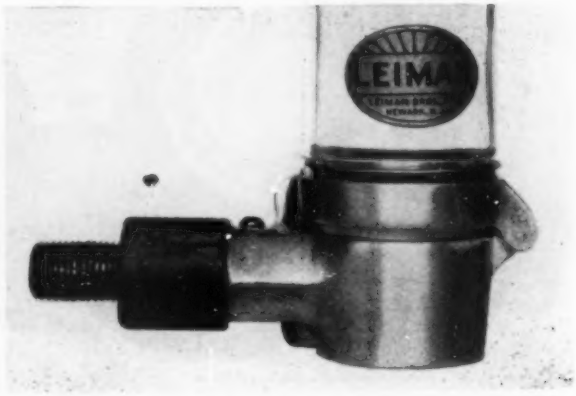
A thermostatically controlled cartridge heater may be installed in the pump to heat any viscous fluids to between 100 and 140 F. The tank has a capacity of $1\frac{1}{2}$ gallons.

Some of the applications are: potting transformers, coils, and capacitor cases; filling condensers and rectifiers; weatherproofing sockets and switches, and impregnating filters. The metering pump for hot waxes and cements is a modification of the standard metering pump, which has been adapted for metering compounds having high melting temperatures ranging from 150 to 450 F.

Edward E. Robinson, Inc., 95 Park Ave., Nutley 10, N. J.

Index Position	Style No. 8025 Discharge C. C.	Style No. 8050 Discharge C. C.	Style No. 8100 Discharge C. C.	Style No. 6100 Discharge C. C.
1	.114	.228	.456	.695
2	.228	.456	.912	1.390
3	.342	.684	1.368	2.085
4	.456	.912	1.824	2.780
5	.570	1.140	2.280	3.475
6	.684	1.368	2.756	4.170
7	.798	1.596	3.192	4.865
8	.912	1.824	3.648	5.560
9	1.026	2.052	4.104	6.255
10	1.140	2.280	4.560	6.950
11	1.254	2.508	5.016	7.645
12	1.368	2.736	5.472	8.340
13	1.482	2.964	5.928	9.035
14	1.596	3.192	6.384	9.730
15	1.710	3.420	6.840	10.425
16	1.824	3.648	7.296	11.120
17				11.815
18				12.510
19				13.205
20				13.900

Automatically Feeding Oiler Reduces Oil Vapor



Specially developed to automatically feed measured amounts of oil to air pumps made by this company, the new E-113 oiler gives adequate lubrication of wings and vanes, yet delivered air is said to be oil-free.

This automatic oiler replaces manual oilers and eliminates the human element. It feeds any oil from SAE 10 to SAE 70. Rate of feed is quickly adjusted from 1 drop in 4 min to 4 drops in 1 minute. It has no moving parts, and feeds only when the pump is running. It can be used on a vacuum pump or on the inlet of a pressure pump.

Leiman Bros., Inc., 146 Christie St., Newark 5, N. J.

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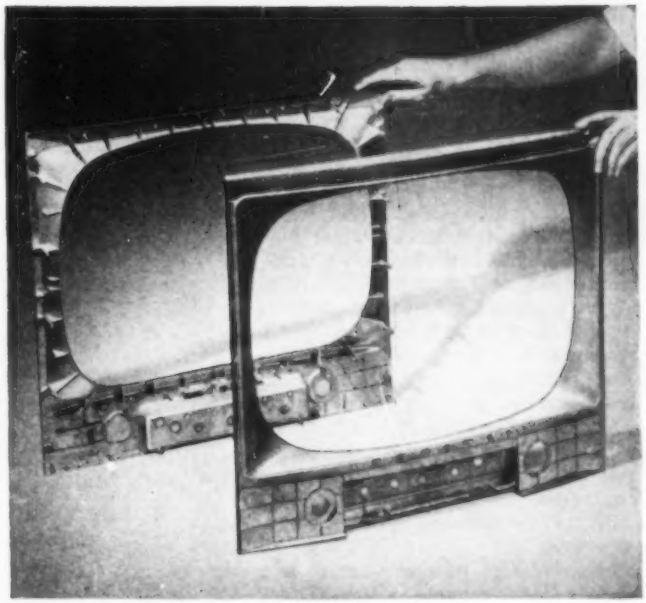


get the mo$t for your Zinc Die Ca$ting Dollar!

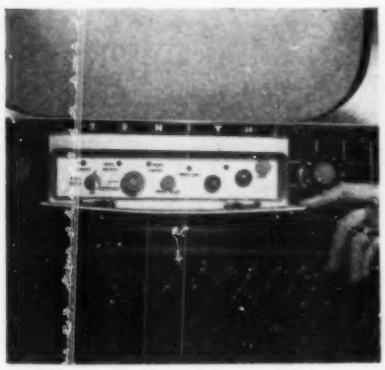
The combination screen and control panel escutcheon for the latest Zenith 21-inch television receiver—shown from both sides above—embodies most of the design and production advantages offered by ZINC Die Casting. How else could the escutcheon have been produced at comparable cost? Consider these details:

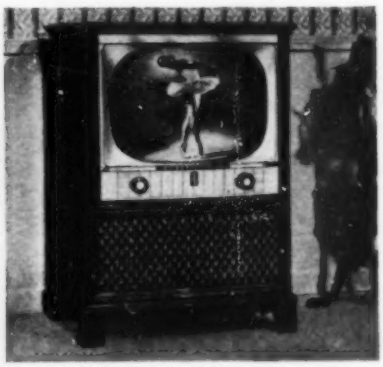
1. Many machining and assembling operations are avoided since all projections, recesses and openings are cast or cored with a high degree of dimensional accuracy in the die casting operation.

2. Cost is further minimized by the high speed at which the ZINC Alloy is cast in a hot chamber die casting machine.

3. Section thicknesses are kept at a minimum to conserve both metal and weight (note the strengthening ribs in the rear view) and there is no scrap loss.

4. Not only are decorative effects faithfully reproduced on the face of the escutcheon, but raised lettering is cast with clean-cut detail (see engraving in the recess behind the control panel door at the left below). The smooth cast surfaces permit low cost finishing with modern organic coatings to provide a gold plated appearance.





GET DESIGN DATA EARLY

The surest way to realize the full physical and economic advantages of ZINC Die Castings is through consultation with a competent die casting engineer in the *early* design stages. Ask any die casting company for help and ask them—or us—for a copy of "Designing For Die Casting."

The New Jersey Zinc Company
160 Front St., New York 38, N.Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

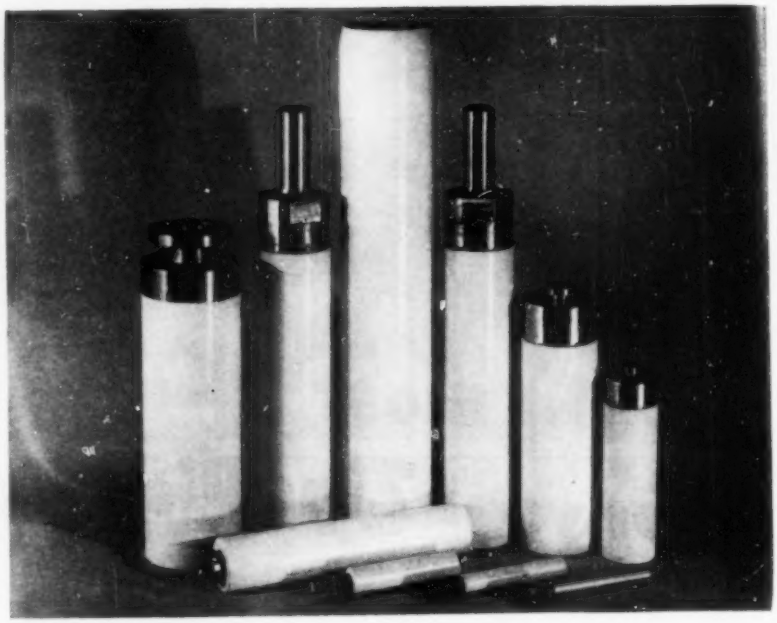
High-Strength Ceramic Pump Plungers

Ceramic pump plungers, said to give long, dependable service under high pressure, corrosive or abrasive conditions, are now being manufactured from high-strength alumina ceramic.

The high-strength ceramic pump plungers have been made for special applications in the oil field and chemical industries, with a variety of designs in sizes ranging from $\frac{7}{16}$ in. up to 5 in. diameter. These plungers are now being used in the chemical and petroleum industries for proportioning pumps and for corrosive and abrasive pumping work.

Basic design of the plungers is a solid piece of ceramic bar stock which is ground on the outside diameter to close dimensional tolerances with highly polished surfaces. Usually one end of the pump plunger body has a reduced diameter to fit into a steel adaptor which connects the plunger to the operating mechanism.

Coors Porcelain Co., Golden, Colo.

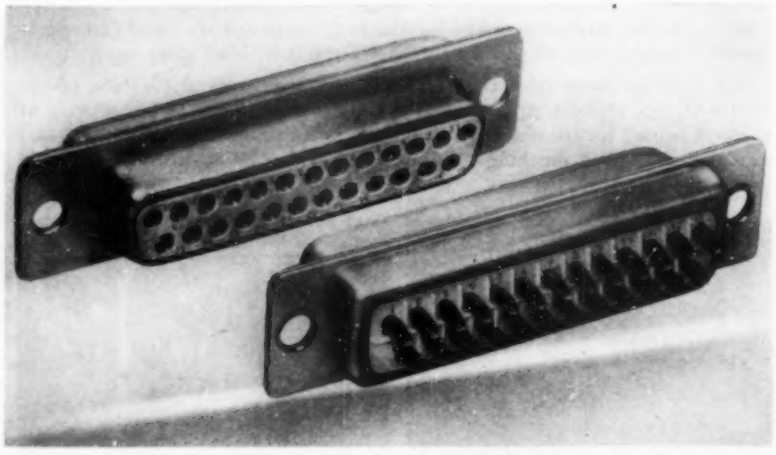


Compact Miniature Connectors

A series of four miniature connectors designated the "D" series has contact complement ranges from 15 contacts to 50, with the smallest having an overall length of $1\frac{17}{32}$ in., depth $\frac{31}{64}$ in., and width $\frac{27}{64}$ in., plus a solder pot extension of $\frac{9}{64}$ inch.

To provide for this compact fitting, changes in materials were made to steel shell and a nylon insulator. The steel shell provides comparable strength to standard aluminum shells and yet maintains a lighter weight. The nylon insulator makes possible high dielectric qualities for the gold-plated 5 amp contacts (no. 20 wire) which have a minimum flashover of 1,500 v a-c rms.

The "D" series may be used as plugs on either side of the assembly by the addition of a junction shell.



Cannon Electric Co., 420 W. Ave. 33, Los Angeles 31, Calif.

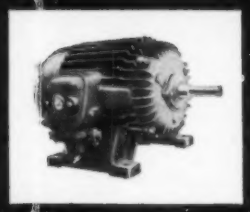
A MAKE AND BREAK DOUBLE SHUT-OFF VALVED COUPLER is gas tight when disconnected, and will not leak during connecting or disconnecting operations. Connection is made by inserting a plug half into the socket half, and turning the seal about $\frac{1}{2}$ inch. The two lugs in the seal cap act as an emergency disconnect. The coupler has a swivel connecting cap so that no twisting of the hose is necessary. The valve is recommended for refrigeration, air conditioning, pneumatic, and hydraulic use. Henry Valve Co., 3215 North Ave., Melrose Pk, Ill.

CONTINUED ON PAGE 238

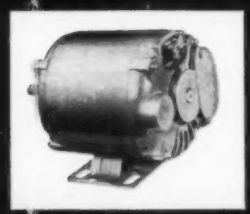
Superior Quality Makes Them The Best Buy In The Country

Vertical Hollow Shaft Pump Motor

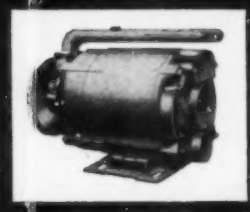
Geared Motor, "SADI"



Totally Enclosed Fan Cooled Motor



Fractional Horsepower Motor



Industrial Sewing Machine Clutch Motor, "Super"

Open Drip Proof Motor

ACEC

FRACTIONAL and INTEGRAL HORSEPOWER ELECTRIC MOTORS

¼ hp. to 200 hp. —all available from stock

Priced below most other motors, ACEC motors offer you the electrical and mechanical excellence that results from over 70 years of experience and scientific research.

THREE-PHASE fractional and integral horsepower motors in ratings from ¼ hp. to 200 hp. are all available from stock. Branches and warehouses are located in New York, Chicago, Kansas City, New Orleans, Houston, Los Angeles—making possible immediate shipments out of warehouse inventories.

Manufactured strictly to NEMA FRAMES AND SPECIFICATIONS, ACEC Motors come in a wide variety of types to meet your motor needs. And 232 ACEC DISTRIBUTORS AND SERVICE SHOPS, located throughout the country, assure prompt and efficient fulfillment of your service requirements.

For top-level motor performance and utmost motor dependability *at lower prices*, write, wire or telephone our nearest representative—or communicate directly with us.

ALL ACEC MOTORS FULLY GUARANTEED

available in the following types:

- ★ **Open Drip Proof Motors**
- ★ **Totally Enclosed Fan Cooled Motors**
- ★ **Pump Motors**
  - **Style "C" Face Mounted**
  - **Style "P" Vertical Solid Shaft**
  - **Vertical Hollow Shaft**
- ★ **Industrial Sewing Machine Clutch Motors**
- ★ **Geared Motors and Capstans**

ACEC CHARLEROI Motors

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Combination Ohmmeter and Leakage Tester

A new combined ohmmeter and leakage tester has a useful range of one ohm to one million megohms, and may be used for making rapid checks of the insulation resistance of transformer windings, condensers, and electrical wiring; as well as measuring the ohmic value of resistors and windings.

The resistance meter is composed of two separate circuits. The four lowest resistance ranges are powered by a 1½ volt dry battery, and a maximum of 1½ volts is applied to any resistance under test in the ranges of R x 1, R x 10, R x 10^2, and R x 10^3. These four ranges are read on the upper scale of the meter. The overlapping point of these ranges is at 50 percent of full scale reading, and a resistance of 10^5 ohms is read with sufficient accuracy on the R x 10^3 range.

For use on the megohms ranges, the instrument is connected to a 105-125 v, 60 cycle, a-c line. From a regulated power supply, 105 v d-c is applied to the unit under test. Full scale reading of the lower meter scale is 0.1 meg., 1 meg., 10 meg., 10^2 meg., 10^3 meg., or 10^4 meg. for the six megohms ranges. The meter will read off-scale for values of resistance less than 1 times the range multiplier and a lower range must be used. Dimensions of the unit are: 10 in. high, 6½ in. wide; and 6½ in. deep. Weight, 10 pounds.

The ohmmeter applies a maximum of 1½ volts to the resistor under test. It has a scale of from 0 to 500 ohms and a selector switch for selecting scale multipliers of x 1, x 10, x 10^2, and x 10^3.

The accuracy of the instrument is plus or minus 3 percent of full-scale deflection for all ranges except the highest of the megohms range which is plus or minus 5 percent.

Southwestern Industrial Electronics Co., 2831 Post Oak Rd., Houston 19, Tex.

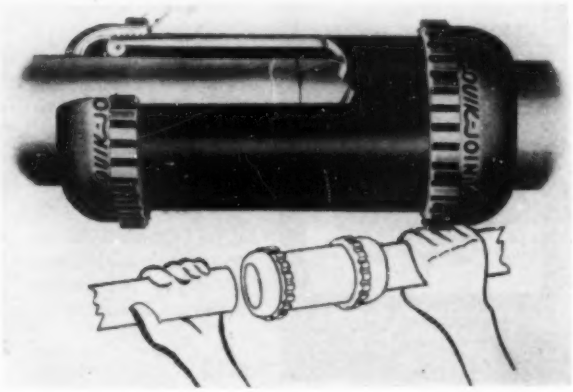
Threadless Type Pipe Connector

A factory assembled pipe coupling which can be installed in any piping system in less than 60 seconds requires no thread cutting and close tolerance pipe measurement. Pipes to be connected are simply inserted into the ends of quik-joint coupling body and the lock nuts tightened.

The result is a flexible joint capable of withstanding working pressures up to 2000 psi. No castings are used and the body is of pressure-tested pipe steel. Lock nuts and gasket retainers are drawn from cold rolled steel.

The joints are now being used with gas, water, air, and oil, and are available in sizes from ½ to 1½ in. IPS as a straight coupling, 90 and 45 deg. ells, welded and threaded adapters. The design allows for up to a 7 degree linear deflection, for connection of pipes out of alignment.

Quik-Joint Mfg. Co., 469 E. 159th St., Harvey, Ill.



LARGE, TOTALLY ENCLOSED FAN-COOLED GEARED MOTORS in the slo-speed line are double reduction and available with Class I, II, and III gears in frame size 364/365, and AGMA speed 155 rpm and slower in ratings from 5 to 25 hp. Widely spaced bearings are mounted in the outer walls of the gear case and gears are mounted between, permitting use of offset shafts, giving permanent bearing and gear alignment in uniform distribution of load. Sterling Electric Motors, Inc., 5401 Anaheim-Telegraph Rd., Los Angeles 22, Calif.

CONTINUED ON PAGE 240

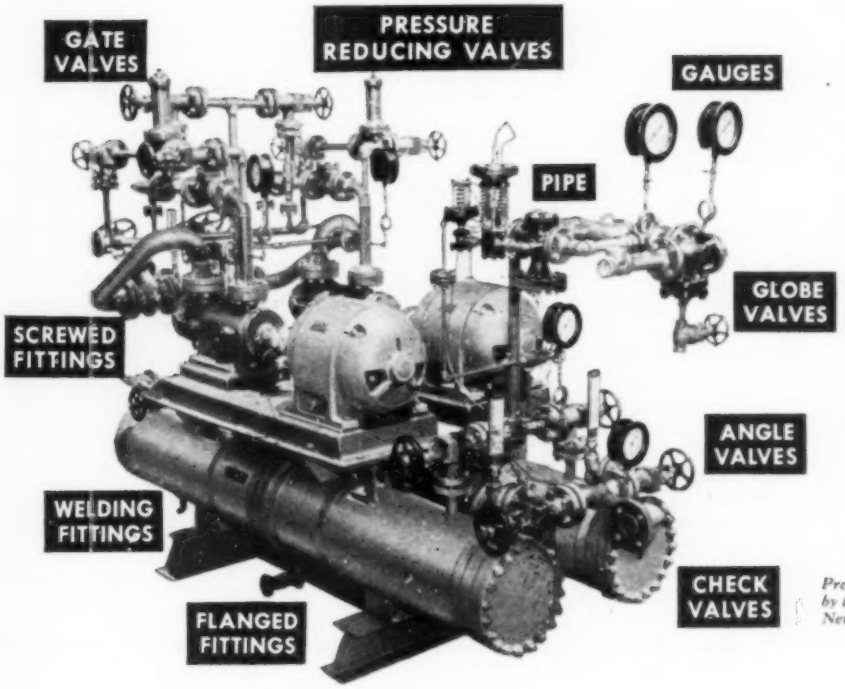
Best book on the subject of piping ...your handy CRANE Catalog

Your Crane Catalog is far more than an index to the world's most complete selection of quality piping materials—it's a complete designer's reference. For each item shown, Crane lists sizes and dimensions, tabulated pressure and temperature ratings, design, material and construction details—plus a run-down of recommended services. This information is conveniently arranged to save you time. Here, too, is an abundance of general engineering information.

And when your product is Crane equipped, you give its buyers the added value of recognized quality piping.

BEST SOURCE OF PIPING QUALITY

...THE COMPLETE CRANE PIPING LINE



Preheater unit manufactured by the Engineer Company New York, N.Y.

FOR GENERAL UTILITY

in high pressure/temperature service, on oil, oil vapor, steam, water, air or gas lines . . . Crane recommends 600-Pound Forged Steel Globe and Angle Valves, O.S.&Y.—Exelloy or Hardened Stainless Steel trimmed. The line includes union bonnet valves with screwed ends in sizes ¼ to ¾-inch or socket-welding ends in sizes ¼ and ⅜-inch; and bolted bonnet valves with screwed, socket welding, or flanged ends in sizes ½ to 2-inch.

The Complete Crane Line Meets All Your Valve Needs. That's Why—
More Crane Valves Are Used Than Any Other Make!

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

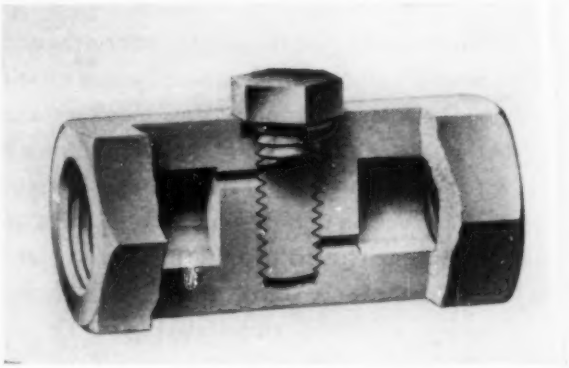
Air Flow Snubber And Pulsation Damper

A new air flow snubber and pulsation damper gives a controlled slow rate of flow of compressed air or gas for operation of continuous-reading hydrostatic instruments and for purging pneumatic instrument lines. It also protects pneumatic testing and gaging equipment against damage that might result from surge pressures.

The snubber is also used as a pulsation damper for pressure gages, recorders, manometers, and similar instruments. Placed in the line between the instrument and the pressure source, the snubber damps or "smooths out" pulsations so that the instrument gives a steady reading.

The snubbing action is accomplished by passing the air or gas through a helical restricting passage nearly 7 inches long around the threads of a screw at right angles to the snubber body. With normally clean air or gas, this restricting passage remains clear and indefinitely. If plugged by dirt, the snubber is put back in operation by cleaning the snubbing screw, without disconnecting from the line.

The snubber is $1\frac{7}{8}$ in. long by $1\frac{1}{8}$ in. maximum over all, and is made of hexagonal brass rod throughout except for a neoprene O-ring used to seal the snubbing screw. Inlet and outlet ends are tapped for $\frac{1}{4}$ in. pipe. Flow rate is approximately 0.04 cubic feet per min. at a pressure drop of 70 psi, and maximum operating pressure is 1,000 psi.



King Engineering Corp., Box 530 Ann Arbor, Mich.

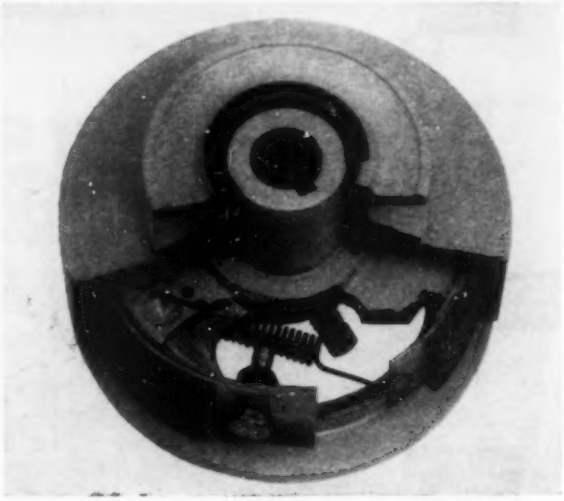
Automatic Centrifugal Clutch For all Engines

A lightweigth, compact, automatic, centrifugal clutch for all standard engines from $\frac{3}{4}$ to 10 hp. engages and disengages at adjustable engine speeds, ranging from 600 to 1500 rpm. Two set screws attach it to motors used to power portable saws and mowers, grain elevators, conveyors, cement mixers and vibrators, winches, motor scooters, midget cars, garden tractors, pumps and standby power units. It can be attached to any standard, American made, aircooled four-cycle gasoline engine.

The clutch has less than a dozen parts. It is operated by centrifugal force, which expands and engages the clutch band at the desired cut-in-speed. This cut-in speed is adjusted by moving the band tension spring, regulating the tension holding the clutch band out of engagement.

The clutch was originally made for the combination mower-saw is now made in three sizes. Shaft and pulley sizes vary, and cut-in speeds are from 1000-1500 rmp on the small model to 600-1200 rpm on the large model. The small model delivers from one to four foot-pounds of torque; the large model from four to twenty. Oilite bearings are used in standard production, with ball and roller bearings available for some models.

Other advantages claimed for the clutch are: load-free starting, with fewer pulls on the starter rope; and smoother, stall-proof engine operation. The clutch assembly is light in weight and small enough to install on any standard crankshaft $\frac{1}{2}$ in. through $1\frac{1}{2}$ inches.



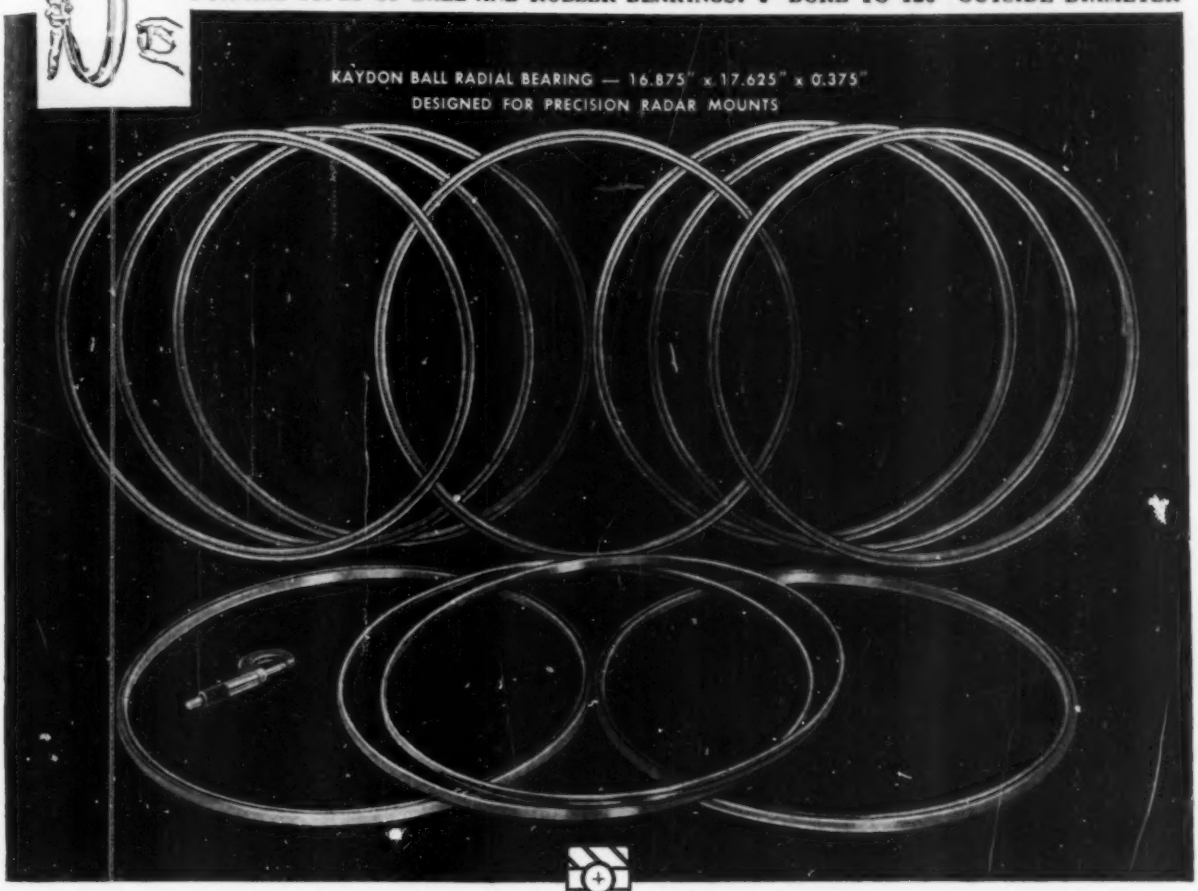
Farm Easy Products, Inc., 1208 East Centennial Ave., Muncie, Ind.

A NEW TERMINAL STRIP is made of ten units molded in one piece, and is so constructed that circuits can be opened and closed for testing by means of a sliding link without disturbing any connected wire. These sliding links are flanged to lock the nuts in place and prevent their turning or contacting neighboring circuits. The strips are made of bakelite with heavy screws molded into place to prevent their turning. The strips may be secured, assembled into switches, fuses, arresters, or in combination. The 8-pole #1500 terminal strip is a smaller unit than the 10-pole #2500 terminal strip. Brach Mfg. Corp., 200 Central Ave., Newark, N. J.

CONTINUED ON PAGE 242

Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER



ACTUAL SECTION: ONLY 3/8" x 3/8"

NET WEIGHT: 2 Pounds

WORLD'S THINNEST BEARINGS

THIN AS A WEDDING RING... WITH THE PRECISION OF FINE WATCH PARTS

Proportionately, that's an understatement! A wedding ring as big as 17.625" outside diameter would be about four times as thick as the actual 0.375" section of these thin KAYDON bearings...and even the finest watch parts, enlarged proportionately, probably would not have the precision tolerance to which these bearings are consistently finished. • These are by far the thinnest ball bearings ever made in this large diameter. KAYDON has developed the facilities and special techniques vital to such precision production.

Precision miracles in extremely large bearings of unusually thin section have become routine achievements at KAYDON. In addition to unique thinness that conserves space and weight, other outstanding features have been embodied in many special KAYDON bearings ...for instance: Flame hardened bearing races drilled, tapped and gear-cut by the KAYDON process eliminate costly auxiliary parts, help improve machine design and performance, and make possible more compact, lighter machines of greater capacity.

For unusually large, light weight, thin section bearings, contact KAYDON of Muskegon.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

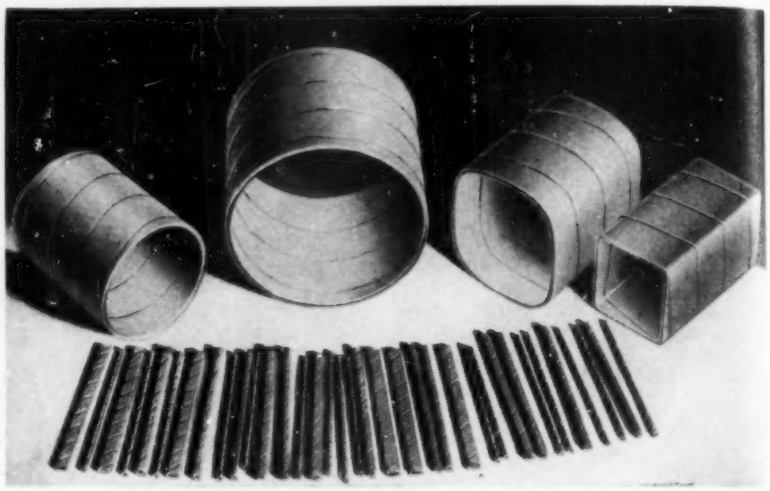
MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

Paper Tubing up to Nine-Inch Inner Diameter

Square, rectangular and radiused paper tubes ranging in size up to 9 inches on either side, and round tubes up to 9-in. inner diameter are now offered in addition to the company's regular line of tubing. They are used in large power transformers and similar large coil applications, such as in x-ray and diathermic equipment.

Tubes are spirally-wound of dielectric kraft, fish paper, cellulose acetate or combinations to all lengths. Since they are produced on adjustable mandrils, any size from fractional-inch to maximum dimensions can be furnished without extra tooling. Acetate overwrap on kraft and fish paper tubes, varnish dip, or resinite impregnation can be had for special applications where increased dielectric properties and unusually high resistance to moisture and corrosion are essential.



Precision Paper Tube Co., 2035 West Charleston St., Chicago 47, Ill.

Sine Curve, Snap-Action Waterproof Switch

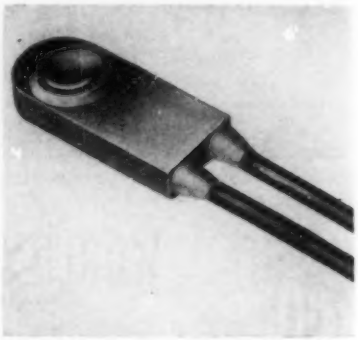
The basic mechanism that operates a new type of sine curve waterproof switch is a type of over-center snap-action motion formed by means of a flat strip of berrylium copper punched out into the shape of a sine curve. This so called sine curve mechanism is stressed longitudinally which causes the two loops of the sine curve to form themselves into opposite helixes. One of the features of this switch is its ability to resist shocks due to its different configuration. The contact is in the middle of two supported ends of the over-center mechanism.

The basic switch illustrated is enclosed in a silicone cover completely sealing the switch from moisture and dirt as well as making it explosion proof and waterproof. Tests indicate that the switch will operate well at minus 65 F or plus 165 F.

The switch can be made in styles including single pole single throw, or double pole-double throw toggle, and push button types of mechanisms.

They are used and approved by the Ordnance Corp. for tanks and other military types of vehicles.

The waterproof switch is rated at 20 amps. resistive load 28 volts d-c and 10 amps. lamp load, 28 volts d-c.



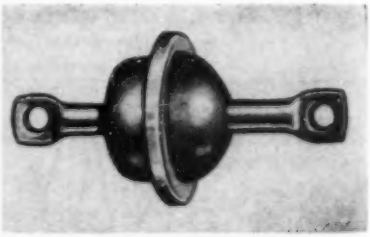
Control Products Inc., Harrison, N. J.

High Temperature Plastic for Terminals

A new plastic material has been developed that withstands continuous temperatures of 200 C and also has a high dielectric strength. It is said to be useful where hermetic sealing and gas sealing under pressure is needed for perfect functioning of electrical components.

The terminal shown is made in three sizes—$\frac{3}{16}$, $\frac{5}{16}$, and $\frac{1}{8}$ in. mounting holes. Applications for this terminal are in the assembly of instruments, meters, and various types of electric and electronic equipment requiring hermetic sealing.

Specifications are: Dielectric strength, 8,000v-60 cps; Corona starting voltage, 2,000 v-60 cps; Terminal pull, 25 lb; Continuous operating temperature, 200 C; Short period temperature 5 min, 260 C; Thermal cycling 4 cycles, —70 C to 200 C; Thermol cycling 4 cycles when soldered ceases, —65 C to 150 C.

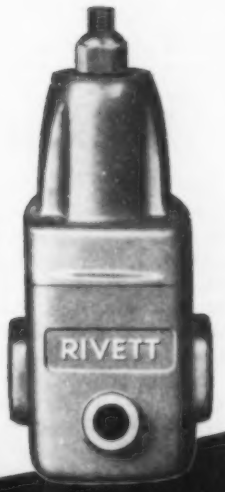


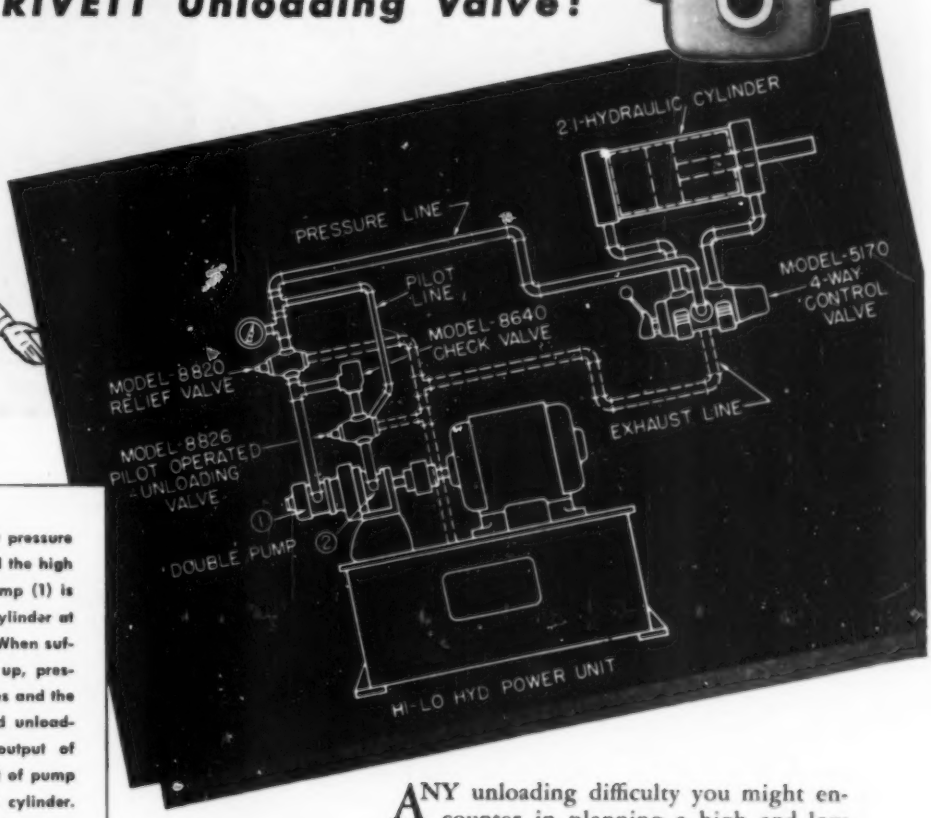
Melkor Research Lab., Inc., 11746 Detroit Ave., Cleveland 7, Ohio

CONTINUED ON PAGE 244

Dumping a Problem—

with this RIVETT Unloading Valve!

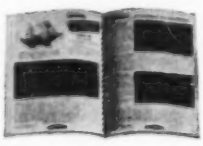




The output of both the low pressure high volume pump (2) and the high pressure small volume pump (1) is directed to the hydraulic cylinder at a low operating pressure. When sufficient work load builds up, pressure in the system increases and the Model 8826 pilot operated unloading valve unloads the output of pump (2) while the output of pump (1) is still directed to the cylinder. Direction of piston travel is controlled by Model 5170 hand operated 4-way control valve.

ANY unloading difficulty you might encounter in planning a high and low pressure circuit can be solved by use of the Rivett Model 8826 Unloading Valve. It is employed in oil hydraulic circuits to unload one part of the circuit at no back pressure to the tank, and is operated by pilot pressure from some other part of the circuit. Free flow to tank continues as long as the pilot pressure is higher than the setting of the valve. Available in sizes ¼" to 1½", in two pressure ranges, adjustable from minimum to maximum in each range. RIVETT LATHE & GRINDER, INC., Dept. PE-12, Brighton 35, Boston, Massachusetts.

RIVETT CATALOG NO. 203 IS A *MUST* FOR YOUR FILE!
28 pages illustrate and describe all types of hydraulic valves.



WHEN YOU APPLY HYDRAULIC OR AIR POWER *Plan with*

RIVETT

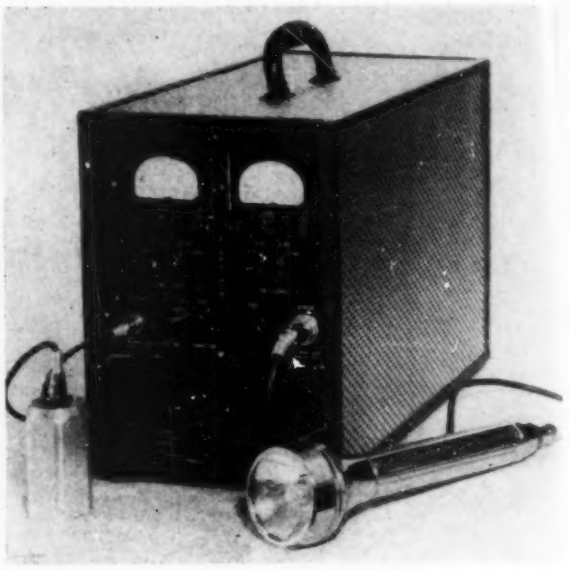
Air and Hydraulic Valves and Cylinders, Hydraulic Power Units.

Portable Dynamic Balancing Machine

The model 652 Vibratron is a portable electronic machine for the analysis, evaluation, and correction of vibration. The device is said to measure accurately and without computation the amplitude and frequency of the vibration and, by means of a stroboscopic light, discover the source. The unit consists essentially of a vibration pickup, a multichannel electronic circuit, and a stroboscopic lamp, and operates on 110 v 60 cycle current.

It can be used to discover and correct unbalance in manufacturing equipment and discover sources of equipment wear. It can be used to synchronize machine speeds and as a detection device for eliminating vibration from remote sources. As production balancing equipment it can be used for dynamic balancing of rotating parts in the range from 600 to 40,000 rpm. By means of a four step switch in the amplitude circuit meter readings can be obtained in full scale from 0.0001 to 0.1 in. peak to peak. The velocity type vibration pickup has an output of 82 millivolts at 0.001 in. deflection at 60 cps. These balancing units may be used on anything from one ounce armatures to 200 hp generators.

International Research & Development Corp., 908 W. Third Ave., Columbus 8, Ohio



Three Piece Gear Motor Simplifies Maintenance

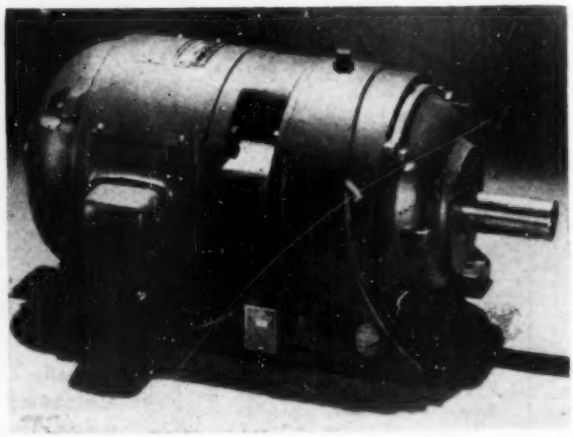
A new gear motor, designed to simplify maintenance in case of electrical failure of the stator, is built in three pieces to permit quick removal of defective stators without disturbing gear components or gear connections to the load. Its design includes a tri-clad motor made by this company; a compact, planetary gear; and a mechanical adapter.

The tri-clad motor construction offers extra protection against operating wear and tear, physical damage, and electrical breakdown. The gear is available in speed ratings of 780 to 13.5 rpm.

The mechanical adapter serves the triple function of acting as the pulley end-shield for the motor, the motor end-shield of the gear housing, and a mechanical spacer for easy accessibility to the stator frame bolts.

According to the manufacturers, the new design will provide maximum continuity of service with minimum spare parts inventory. It is expected to cut stator replacement time in half, they said.

The stator can be changed with the removal of only bearing-enclosure screws, the bolts that hold the front end-shield to the stator, and bolts holding stator to the motor adapter. A defective stator can be replaced by either another round-frame stator or by an ordinary, standard-motor adapter. A defective stator can be replaced by round-frame stator or by standard-motor stator. The new motor is available in ratings of 1 to 75 hp for standard applications and up to 200 hp for special applications.



General Electric Co., 1 River Rd., Schenectady 5, N. Y.

NEW ELECTRIC COUNTER ACTUATING SWITCHES, equipped with wheels have been developed for use in measuring paper, fabrics or lumber. A bracket holds one end of the switch in a fixed position permitting the wheels to ride on and be turned by the material being measured. Each complete revolution of the wheels closes and opens the switch, giving the impulse to register a count in an electric counter. The wheels are 12 in. in circumference, but other sizes can be furnished. Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.

CONTINUED ON PAGE 246

L-O-N-G CREEPAGE PATH assures electrical performance

. . . when you use T & B Self-Insulated Sta-Kon® Terminals*

Terminal *insulation* extends beyond the terminal *body* in new T & B Self-Insulated Sta-Kons. That means a *longer* electrical creepage path — *extra* assurance of equipment performance!

These new components eliminate risk of shorts between closely-mounted terminals. Metallic portion retains all the proved advantages of the Sta-Kon design — high conductivity, permanent grip. Lightweight nylon insulation prevents metal-to-metal contact between terminals . . . *without* an extra insulating operation. It withstands action of gasoline, naphtha, hydraulic fluids. It's *color-coded* for quick identification — *translucent* for easy inspection.

SIMPLE, SURE ASSEMBLY

One operation stakes terminal to wire with terrific force . . . holds wire insulation firmly inside terminal. SHURE STAKE®† Hand Tools apply 1-ton staking pressure *every time* — jaws can't open till full force is exerted. Air tools available too — hand-held or bench-mounted.

ENGINEERED RIGHT— DISTRIBUTED RIGHT

Self-Insulated Sta-Kon Terminals are typical of the many T & B quality fittings recently re-designed to give you outstanding performance at lowest installed costs. Like all T & B fittings, they're furnished 100% through local T & B distributors under the T & B Plan.

*Patent applied for †Patent Pending

THERE'S A T&B ENGINEERED PRODUCT for every wiring job in the complete T & B line of fittings for all conductors and raceways.

THE THOMAS & BETTS CO., INCORPORATED

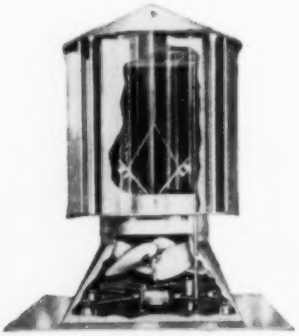
16 Butler Street, Elizabeth 1, New Jersey

MANUFACTURERS OF ELECTRICAL FITTINGS SINCE 1898
ORIGINATORS OF SELF-INSULATED SOLDERLESS TERMINALS IN 1935

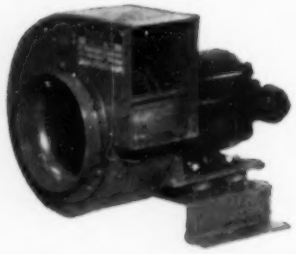
Our Field Design Engineers are ready to help you on special fittings problems. Ask your nearest T & B Distributor to arrange to have one get in touch with you.

SHOCK AND VIBRATION NEWS

Exhaust Fans Quieted by Vibration Isolators



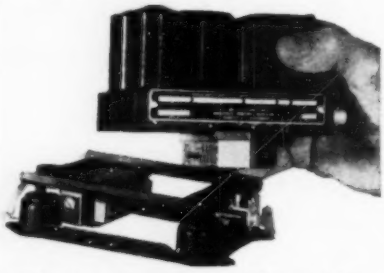
The problem of motor and fan noise is successfully overcome in the Breidert Air-X-Hauster by use of four air-damped Barrymounts that support the low-speed motor and fan assembly. These isolators absorb the motor and fan vibration, keeping it from reaching building members or metal ducts along which it would otherwise be carried or amplified. To assure adequate isolation, the mountings used were type 990 Barrymounts having a natural frequency of only 8 cps.



Another example of use for Barrymounts in ventilating systems is with the high-speed Westinghouse-Sturtevant multi-vane, railway car fan. Here they isolate fan vibration for quieter operation and protect the assembly from the shocks incidental to mobile service. In this application, type C-2000 Barrymounts were used to provide protection against forces applied laterally as well as vertically.

Your vibration or noise problem may be solved by a simple application of Barrymounts. Ask our Field Engineering Department; they'll gladly help you. Or write for Catalog 504-B, describing Barrymounts for a wide variety of uses.

Miniaturized Vibration Isolators Help Cut Space and Weight in Fuel-Gauge Power Unit



70% size reduction and 50% weight reduction — with no loss of performance — is the effective miniaturization obtained in the new Minneapolis-Honeywell aircraft-fuel-gauge power unit. Miniature, air-damped Barrymounts, Type 6465, helped M-H engineers in this achievement.

These vibration isolators, in which size and weight have been cut while operating characteristics have been maintained, will help you redesign for miniaturization.

Check these useful features of miniaturized Barrymounts.

Light weight — only 5/16 ounce each.

Small size — 1" diameter 11/32" loaded height.

Resonant frequency — 9 cps

Transmissibility at resonance — 3

Wide load range — 0.1-3 pounds

4 different styles available — for plate or stand-off mounting.

Write for data sheets 605 and 606 giving details of dimensions and load ratings.

FREE CATALOGS

- 523-A — Air-damped Barrymounts for aircraft service; also mounting bases and instrument mountings.
- 509-A — ALL-METL Barrymounts and mounting bases for unusual airborne applications.
- 504-B — Shock mounts and vibration isolators for marine, mobile, and industrial uses.
- 607 — How to cut maintenance costs by using Barrymounts with punch presses.

THE **BARRY** CORP.

730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

Atlanta Chicago Cleveland Dallas Dayton Detroit Los Angeles Minneapolis New York Philadelphia Phoenix Rochester St. Louis San Francisco Seattle Toronto Washington

Pocket-Size Volt-Ammeter

The amprobe 300, a new pocket-size volt-ammeter with nine ranges up to 300 amps and 600 v is of the snap-around type, allowing the user to measure current without shutting down equipment or making ammeter connections.

This one instrument covers nine ranges: 0-6/15/30/60/150/300 amps a-c, 0-150/300/600 volts a-c. Voltage test leads are equipped with new retractible safety plug, which automatically insulates itself when removed from the meter. Jaws are completely insulated down into the sockets, protecting against shorts and shocks. The instrument is pocket-size and belt-mounting.

Some of its uses are: determining load conditions, checking motor overloads, balancing loads, locating grounds, tracing shorts, start and run currents, relay settings, checking open windings in motors, checking voltage losses, and checking out controllers.

Pyramid Instrument Corp., Lynbrook, N. Y.

Miniaturized Plug-In Amplifier

A new miniaturized plug-in a-c feedback amplifier employs two pentode voltage amplifiers and a beam power output stage, and has a power output of approximately three watts. It is said to have a wide application in audio and servo mechanism fields, and is ideal for driving two phase servo motors in systems where space is limited and ease of maintenance a necessity.

The feedback resistor is connected

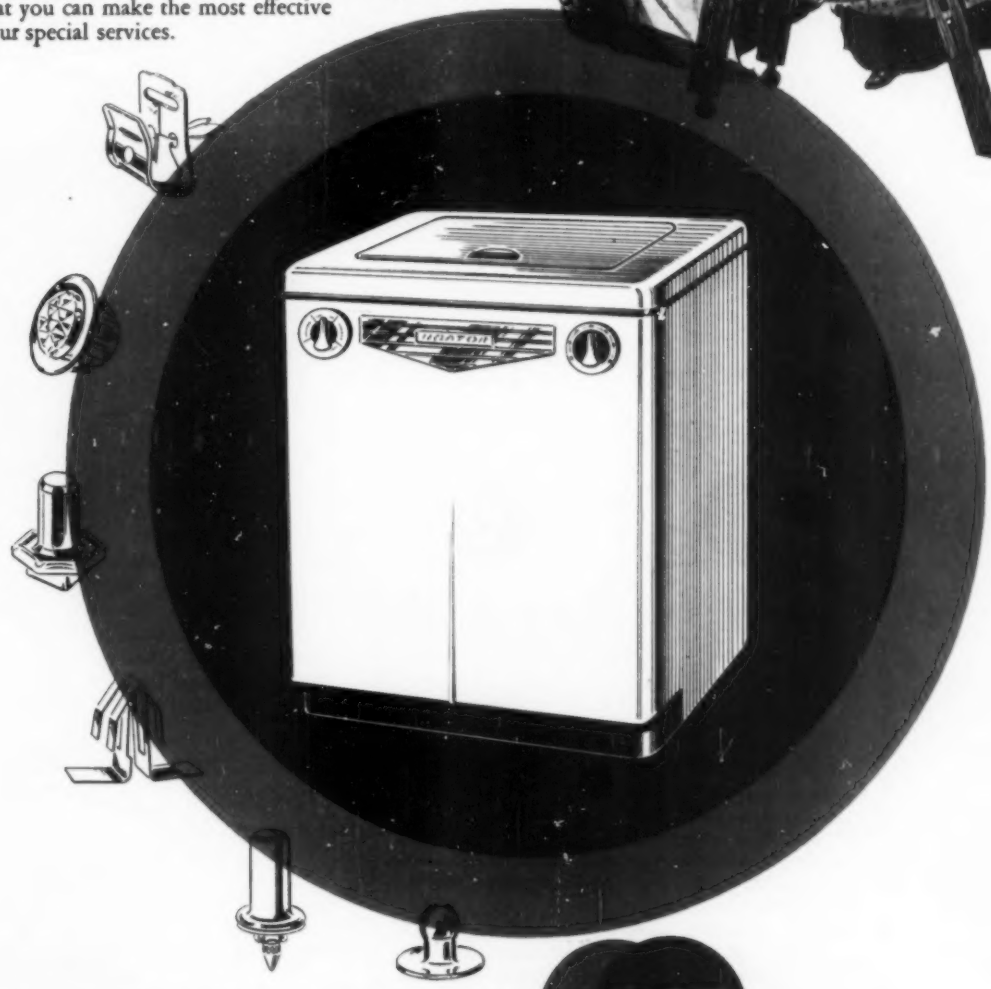
HAVE YOUR FASTENING METHODS

kept pace?

It's a long way from the zinc-lined scrub-boxes Great-grandmother knew to today's streamlined home laundry...and design changes come faster than ever these days. That's why it pays to have your fastening methods checked by trained specialists . . . constantly.

United-Carr offers you ★ Complete engineering and design service. ★ Complete facilities for volume production of specialized fasteners and allied devices. ★ Wide experience with the top manufacturers of appliances, automobiles, aircraft, electronic equipment, furniture. ★ The varied technical knowledge of all our divisions and subsidiary companies combined . . . to help you cut costs, speed assembly, improve product performance.

Call your nearest United-Carr field engineer *before* your new designs crystallize. It is in this all-important *planning* stage that you can make the most effective use of our special services.



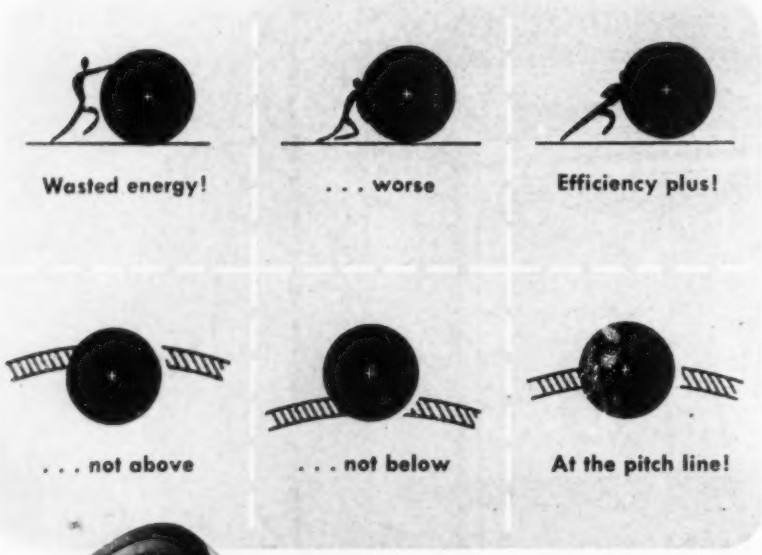
UNITED-CARR DOT **FASTENERS**

UNITED-CARR FASTENER CORP., CAMBRIDGE 42, MASS.

TAILOR-MADE IN VOLUME QUANTITIES

RBC's

PITCH CIRCLE ALIGNMENT
for PEAK EFFICIENCY



• Aligned at the *pitch circle*, the most efficient plane for roller guidance, PITCHLIGN rollers are not subject to the internal stresses incurred in other bearings where the cage acts at a point above or below, the pitch circle. In PITCHLIGN bearings, tangential forces are virtually eliminated, since the cage acts *only* in the direction of rotation and at a point coincident with the roller orbit.

PITCHLIGN'S performance potential far exceeds that of precision needle-type bearings. Rollers cannot cock or skew! PITCHLIGN is interchangeable with precision needle bearings, of course. Get the facts! ***Write for Bulletin SF-166***

RBC

ROLLER BEARING COMPANY OF AMERICA • TRENTON, N. J.

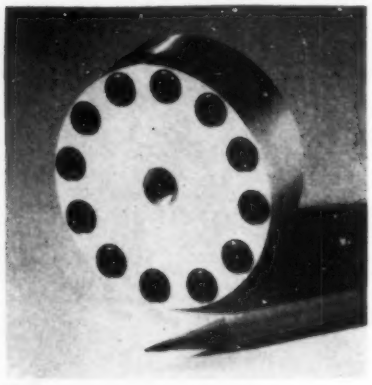
to terminals on the receptacle so that it will be possible to get any desired gain with a single basic amplifier which features a high open loop gain, sturdy construction and JAN components. The amplifiers are supplied with mating receptacles. Models of the miniaturized amplifier are available employing voltage or current feedback.

The I. & O Research & Development Corp., 515 S. 15th St., Philadelphia, 2, Pa.

Isolator Protects Instrument System

Known as the type 40 Isolator, this device separates corrosive liquids or gases from liquid filled pressure gages and other instrumentation systems, and will permit standard commercial pressure transducers to be used for pressure measurements of highly corrosive agents.

The isolator uses a Kel-F diaphragm to separate the corrosive medium from



the instrument system, and is capable of transmitting pressures with negligible drop. The isolator may be used at line pressures as high as 1,000 psi, with special 3,000 psi units available, and will hold back the total line pressure in case of instrument failure.

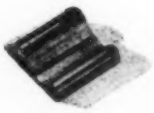
Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.

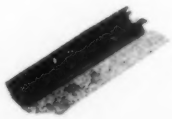
Spring Tester For Small Springs

Loads and deflections of small compression and extension springs are accurately measured by a precision spring tester having a load range capacity from ½ oz to 25 lbs. The scale is accurate to within ¼ of 1 percent and steel rules measure lengths in 32nds and 64ths on one side, and in decimals in 10ths and 100ths on reverse side. A 1 in. capacity dial indicator

THE MAGIC OF *Silicone*

RUBBER PARTS FABRICATED BY STALWART

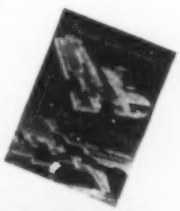




ONLY SILICONE RUBBER PARTS can withstand temperatures ranging from +500° to -110° F. Because of their extraordinary properties, silicone parts have excellent resistance to weathering, oxidation, moisture, ozone, permanent compression set, and many chemicals and oils.

SILICONE PARTS FABRICATED BY STALWART assure maximum performance and maintain their desirable physical, chemical and dielectric properties under critical operating conditions. In many applications, they have replaced metal fabrications forced upon manufacturers by the limited thermal stability of organic rubbers. Silicone rubber parts now are used for many difficult applications . . . aircraft seals and instruments, marine equipment, transformers, internal combustion engines, motors, generators, chemical and electronic equipment, etc.

EXPERIENCED STALWART ENGINEERS are prepared to mold, extrude, punch, machine-cut and mandrel-build precision silicone rubber parts to meet individual as well as S.A.E. and A.S.T.M. specifications.



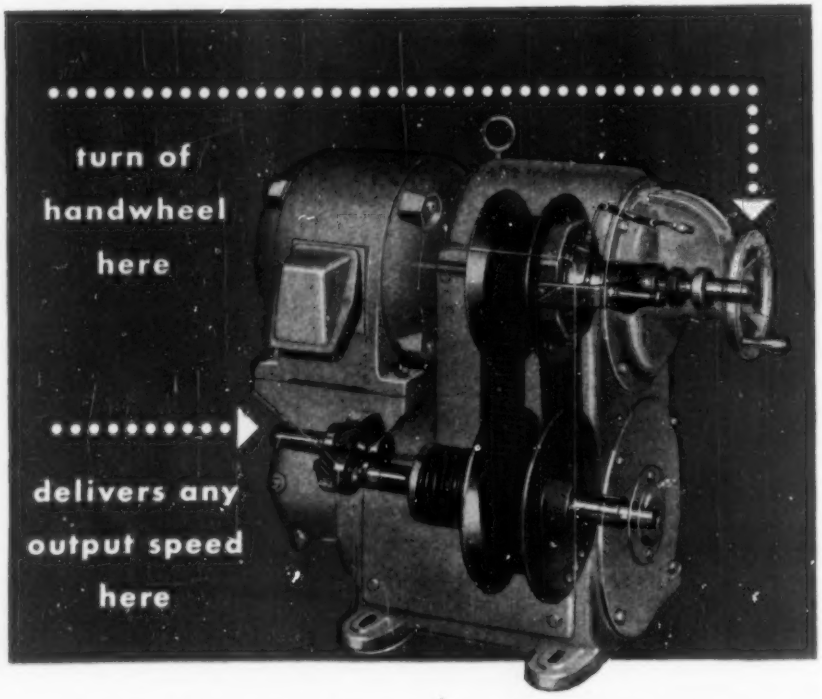
Write today for CATALOG 515R-1 for additional information.

512-SR

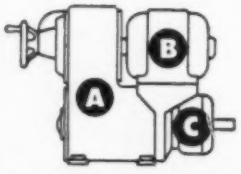
STALWART RUBBER COMPANY

200 NORTHFIELD ROAD • BEDFORD, OHIO

Simplify your speed-changing methods with Reeves Vari-Speed Motodrive®



A complete, variable speed power plant in one, compact package that releases the *full* profit potential of every machine . . . every operator



REEVES Vari-Speed Motodrive incorporates (A) REEVES speed-changing mechanism, (B) any standard, constant-speed motor, and (C) gear reducer in a single, space-saving unit easily applied to any machine. Turn of handwheel or touch of button delivers any desired speed—instantly, accurately, *positively*—without stopping the machine. Widens machine work range; increases rate and quality of production; and utilizes highest skill of operator. Specify REEVES Vari-Speed Motodrives for the machines you build or buy. Sizes to 25 hp; speed ratios as great as 10 to 1. Send for free catalog to Dept. K-20.

REEVES PULLEY COMPANY • COLUMBUS, INDIANA
Recognized leader in the specialized field of variable speed control

REEVES Variable Speed Drives
for *accurate* speed control

measuring lengths and deflections to 0.001 in. is available.

Adaptable for both general purpose and high quantity production testing, the speed of testing varies from 250 to 500 tests per hour. Springs with diameters up to 2 in. and lengths up to 10 in. can be tested.

The Carlson Co.,
277 Broadway, New York 7, N. Y.

Ball Bearing Idler Rollers

Crown faced idler rollers with precision-type radial and thrust ball bearings are protected by felt and metallic seals and can be lubricated through the ends of the shafts. The rollers can be mounted in horizontal or vertical position or at any angle for use with light weight power conveyors and various types of industrial equipment.

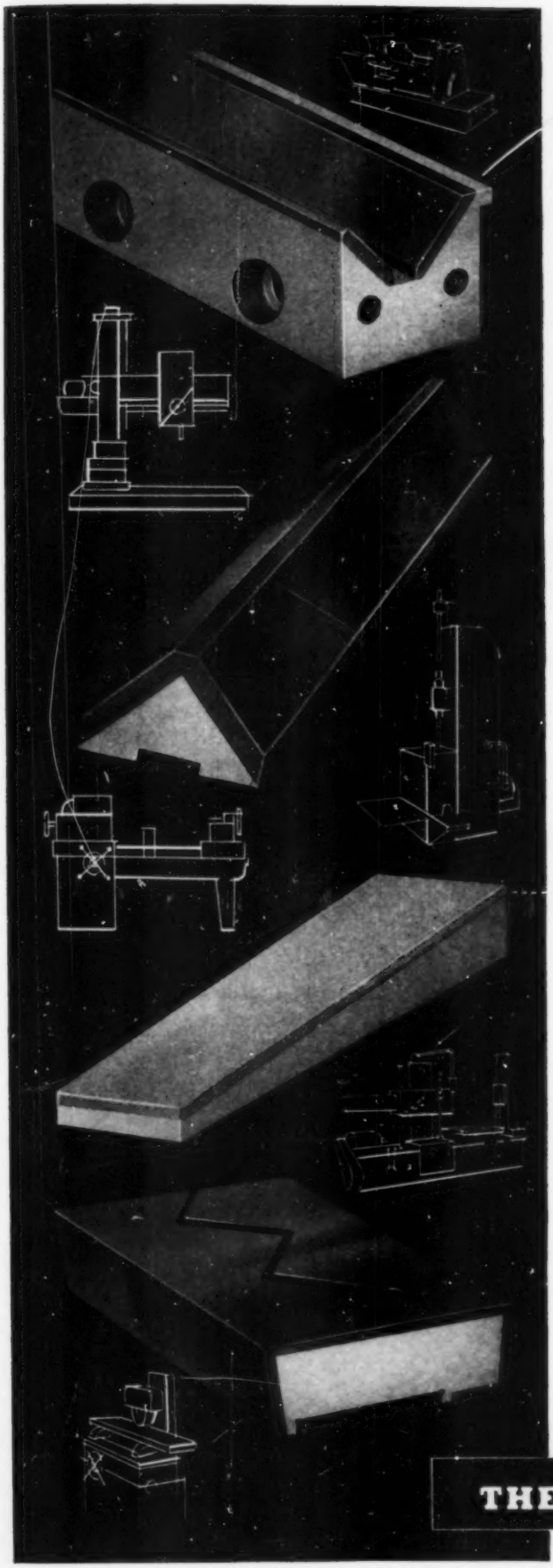
Available in 2⅝ in. and 4½ in. diameter, with widths to specifications.

Samuel Olson Mfg. Co., Inc.,
2418 Bloomingdale Ave., Chicago 47, Ill.

Reducing Regulator and Pressure Gauge for Compressed Air

A combination reducing regulating valve and pressure gage for all compressed air purposes is furnished in four sizes: ¼, ⅜, ½, and ¾ in. pipe size connections. The valve is provided with a special metal bracket, and two vibration dampeners are furnished with each regulator and gage, thus eliminating shock and concussion blows generated by the equipment.

The regulating valve reduces the



it's OK

let'em go with OK hardened ways, gibs, ball races, and Ampco bronze wear strips

The ultimate success and accurate life of your machine depends to a large extent on the accuracy, and uniform high hardness of its ways, gibs, ball races or wear strips. OK parts are the finest. They are made of special tool steel welded to a backing of soft tough steel under 2500 tons pressure, then hardened to a Rockwell C-65-66 and ground to tolerances of ± .00015 (both straight and parallel). They are available in all sizes and shapes, to meet your particular requirements.

OK wear strips are now available in welded Ampco bronze. Because of the OK's special bi-metal method of welding, less bronze is required. These ways are ground to close tolerances thus reducing manufacturing and assembly time.

Mail coupon below for comprehensive bulletins.

Manufacturers for the Metal Working Industry of Slitter Knives, Shear Blades, Rotary Shear Knives, Hardened Spacers, Hardened Ways, Gibs, Ball Races, Bronze Ways, and Wear Strips.

OHIO KNIFE CO., DEPT. B
Cincinnati 23, Ohio

Please send free Bulletins on OK ways, gibs, etc.

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THE OHIO KNIFE CO.

CINCINNATI 23, OHIO

Reasons why another

COUPLER HOUSING switched to UNITCASTINGS!

This warehouse trailer coupler housing is subjected to considerable stress and strain in handling materials for general factory use. As a weldment, it not only used 40 inches of welding, slowing down unit production, but lacked eye appeal.

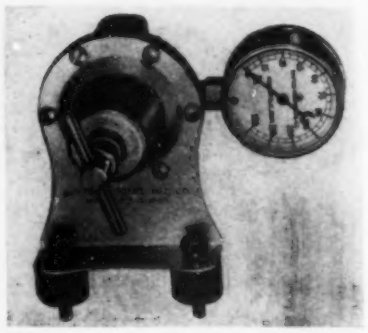
After the switch to Unitcastings, production costs dropped 25%, trailer performance improved, a streamlined appearance added more "saleability" to the product . . . and with an eye to future repeat orders, Unitcastings created better customer relationships. To build quality into your own product, trust it to UNITCASTINGS—they're better.

UNITCAST Corporation

QUALITY STEEL CASTINGS

Give us a chance to offer a "cast steel" answer for your parts problem. Our suggestions while your product is in the design stage will pay continuous dividends. Write or call today. Unitcast Corporation, Steel Casting Division, Toledo 9, Ohio. *In Canada:* Canadian-Unitcast Steel, Ltd., Sherbrooke, Quebec.

UNITCASTINGS ARE FOUNDRY ENGINEERED



shop air line (primary pressures) to the lower desired secondary pressures (max 150 lb) automatically, thus maintaining such pressures with the minimum attention.

This pressure gage records at all times the primary pressure used or wanted on the piece of equipment at the point of operation and can be furnished with or without pressure gage. The reducing regulating valve is also furnished with a stop nut or lock nut, to permit locking of the adjusting screw handle.

Dayton Rogers Mfg. Co., 2824 13th Ave., Minneapolis 7, Minn.

Liquid Plastic in Pressurized Containers

Considered good as insulation for radio, television, and electronic components and wiring, a new clear liquid methacrylate plastic is now available in pressurized containers, and is applied as a spray.

Called Plastik 707, it is unaffected by exposure to acids, alkalis, chemical fumes, the sun, water or salt spray. Used on linoleum, or wood floors, it seals the surface against staining and wear by providing a high gloss protective film that requires no scrubbing or waxing. It may also be used for the preservation of documents, maps, prints, shipping labels, photographs and paintings.

The United Technical Labs., Morristown, N. J.

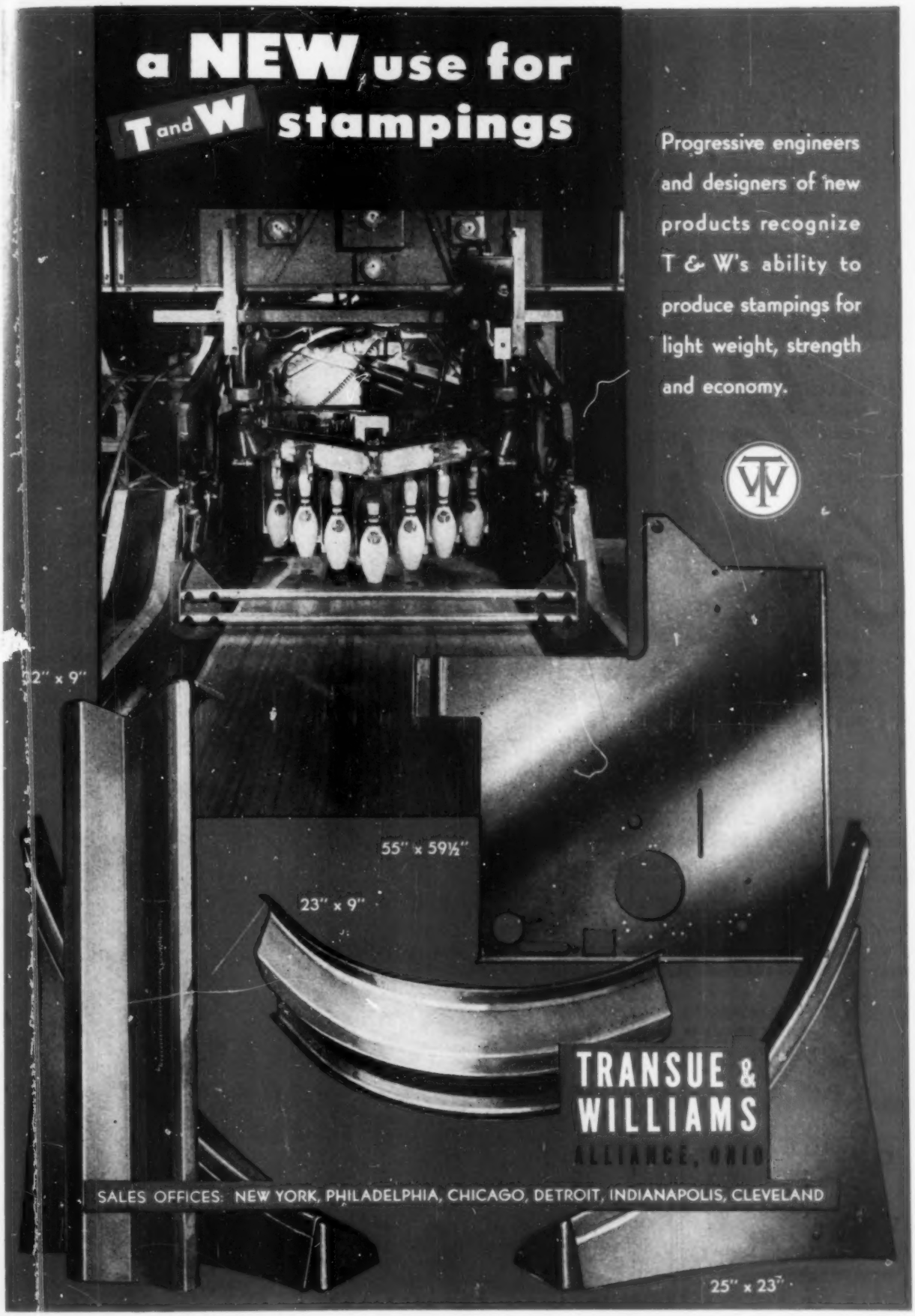
Small Light Weight Transformers for Audio Use

A line of hermetic sealed transformers covers the entire range of audio requirements for sub-miniature equipment and include input, interstage and output transformers, as well as a reactor.

The overall case dimensions of these units are only $\frac{1}{2} \times \frac{11}{16} \times \frac{33}{32}$ in. which is said to be roughly half the volume

a NEW use for T and W stampings

Progressive engineers and designers of new products recognize T & W's ability to produce stampings for light weight, strength and economy.



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ALLIANCE, OHIO

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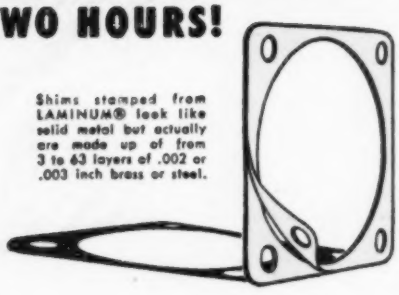
2 Seconds

CAN SAVE YOU TWO HOURS!



Shims stamped from LAMINUM® look like solid metal but actually are made up of from 3 to 63 layers of .002 or .003 inch brass or steel.

Adjusting bevel gear mesh with a laminated shim is a matter of two seconds to remove a lamination!

The shim in this case is made of LAMINUM®, our exclusive material. It is a "solid" unit built up of 16 layers of .002 brass. It peels quickly and easily. Each shim removed adjusts the bevel gear position by two thousandths.

You save time by easier machining tolerances on the housing; ***you save time*** by eliminating pesky assembly machining; ***you save*** by not tying up a machine intermittently. IT'S EASIER!

SEND FOR LITERATURE

LAMINATED SHIM COMPANY, INC.

SHIM HEADQUARTERS SINCE 1913

Check Our Stampings Division For Your Stamped Parts Requirements

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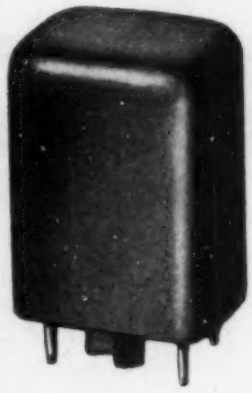
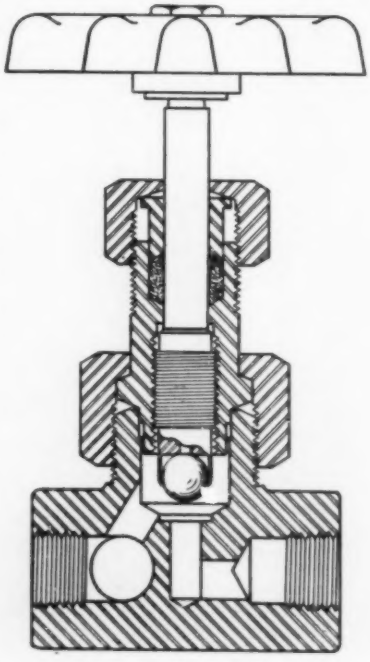


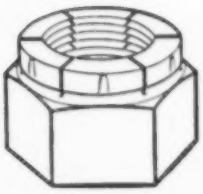
of any miniature hermetics available today. Units weigh only 0.8 ounce. This miniaturization is made possible through the use of special nickel iron alloy laminations and fine wire windings on a nylon bobbin. Mounting is effected through a single threaded stud arrangement with case tabs.

United Transformers Co., 150 Varick St., New York 3, N. Y.

Ball Valve for 3,000 Psi Operation

A new ¼ in. ball valve recommended for working pressures up to 3,000 psi. has a tight, positive shutoff provided by a stainless steel ball which closes into a machined, conical seat. The ball, retained at the end of the stem, is free-rolling so that every closing brings a new surface into contact with the valve seat. The long-stroke





FLEXLOC Self-Locking Nut

Just what are these Flexloc nuts?

"They're nuts that lock and stay put on a bolt. Once you install them, you can forget them. They sure save a lot of time in maintenance. Let me show you just what I mean. This shuttle assembly is fastened together with FLEXLOC *Self-Locking Nuts. We haven't had to put a wrench on it since we installed it."*

When nuts work loose, you're in real trouble. Machinery is often damaged and stopped. Production suffers, deliveries lag, and you lose money. But there's a sure way to keep nuts where they belong. Specify and install FLEXLOC Self-Locking Nuts.

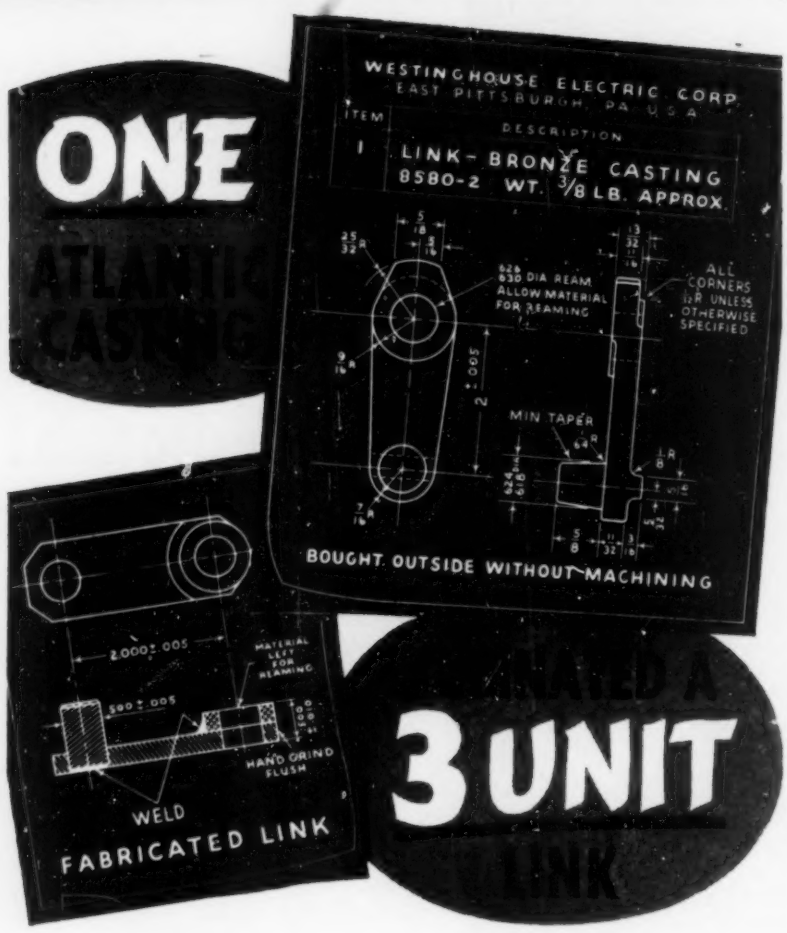
FLEXLOC locknuts have higher tensile strength than most other locknuts. They're not affected by temperatures to 550°F. And because their torque is controlled within such narrow limits, they have been used successfully on plastic studs.

Increased capacity now enables us to make quantity shipments of FLEXLOC locknuts in a wide range of sizes. Write for literature, and samples. STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.

FLEXLOC LOCKNUT DIVISION

sps

JENKINTOWN, PENNSYLVANIA



FOR Westinghouse!

Westinghouse Electric Corp. recently required a part for use on oil circuit breakers. Their rough blueprint called for a link composed of three separate units which had not only to be machined, but welded together.

Atlantic's engineers suggested a design that resulted in a part cast in ONE PIECE from Atlantalloy #31 High Tensile Manganese Bronze . . . a dependable engineering material that is stronger than many steels. This one piece casting eliminated the involved machining, welding and finishing steps—and consequently afforded a substantial saving over former costs.

Write for a copy of "Quality Precision Castings for Industry" today. This booklet shows how the plaster mold process cuts production costs and includes specifications on Atlantic's alloys.

ATLANTIC CASTING and ENGINEERING CORP.
Established 1937
721 Bloomfield Avenue • Clifton, N. J. • PRescott 9-2450

stem and the packing gland are made of stainless steel. The packing is a preformed, graphited asbestos with a plastic binder and can be replaced without shutting off the line pressure or interrupting the process. Straight-through and angle types are available with two and four connections.

Applications are on meter manifolds, gage lines, seal chambers, bleed-off connections, sampling connections and lubricator shutoffs, liquid, gas, and steam.

The Foxboro Co., Foxboro, Mass.

A NEW PHILIPS GAGE, type PHG-09, which covers a range of 8,000,000:1 on a single meter from a single pick-up can be used to read vacuums from 0.50 mm to 10^{-7} mm Hg. The all metal pick-up tube works on the glow discharge principle. In the tube, permanent magnets provide a field which lengthens the electron paths into tight spirals that give high ionization per electron, with a cascade effect. Having no filament to burn out, the tube can be operated at full atmosphere without damage. In addition, the circuit is insensitive to fluctuations in line voltage. Distillation Products Industries, Ridge Road West, Rochester 3, N. Y.

A MULTIPLE TUBE PURGE METER in a single integral unit is available in two, four or six tube units. This plastic rotameter replaces a similar number of single tube meters or bubblers for metering and regulating small flows of liquids or gases. All of the metering tubes and piping connections are precision-bored in a block of acrylic plastic, eliminating packing glands and breakable glass tubes. The meter is available with either a common manifold inlet for all the metering tubes or individual inlets. Rate of flow adjustment is made with separate needle control valves for each tube. In addition, a standard bezel is obtainable for flush panel mounting. Brooks Rotameter Company, Box 432, Lansdale, Pa.

A NEW LOW VALUE MOLDED CAPACITOR, Type CAS, measures $\frac{13}{32}$ in. long x $\frac{1}{8}$ in. dia, and has been designed to obtain small values of capacitance with high Q for its range. At present it is being manufactured in standard values from 0.22 mmf to 2.2 mmf, ± 20 percent standard tolerance. Molded in thermosetting material, it is protected for all applications requiring an insulated capacitor, particularly where small value capacitances are required. International Resistance Co., 401 North Broad St., Philadelphia 8, Pa.

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Aircraft Reciprocating Engines
Automotive Accessories
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If *you* have a shaft sealing problem, Gits experience in these and many other specific applications can prove of great and immediate value to you.

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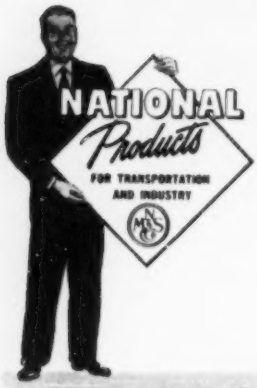
selected for Quality and Dependability



Products bearing these familiar trademarks have all established enviable reputations for quality and dependability. These manufacturers *continue* to procure castings by National—one of the Nation's largest founders.

National's unparalleled experience in producing malleable, heat-treated malleable, and steel castings is at your disposal. Sales offices and engineering facilities are located at all five strategically located plants. A-5346

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A 16mm technicolor film. Narrated by Edwin C. Hill, this 27-minute film tells how malleable iron is made . . . tested . . . used . . . how its production economy, ductility, machinability, toughness will give you a better finished product. Available for group showings.

NATIONAL Products FOR TRANSPORTATION AND INDUSTRY

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CLEVELAND 6, OHIO Est. 1868

MEETINGS

December 10-13

AUTOMOTIVE SERVICE INDUSTRIES SHOW—Convention Hall, Atlantic City, N. J.

December 17.

INSTITUTE OF THE AERONAUTICAL SCIENCES—Sixteenth Wright Brothers Lecture, U. S. Chamber of Commerce Building, Washington, D. C.

January 12-15

AMERICAN MANAGEMENT ASSOCIATION—General Management Conference, Hotel Statler, Los Angeles, Calif.

January 12-16

SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting and Engineering Display, Sheraton-Cadillac Hotel, Detroit, Mich.

January 19-22

PLANT MAINTENANCE CONFERENCE AND SHOW—Public Auditorium, Cleveland, Ohio.

January 23

MALLEABLE FOUNDERS' SOCIETY—General Meeting, Hotel Cleveland, Cleveland, Ohio.

January 26-29

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

January 26-30

INTERNATIONAL HEATING AND VENTILATING EXPOSITION—International Amphitheatre, Chicago, Ill.

February 3

AMERICAN ASSOCIATION OF TEXTILE TECHNOLOGISTS—Annual Convention and Exhibition, Hotel Statler, New York, N. Y.

February 4-6

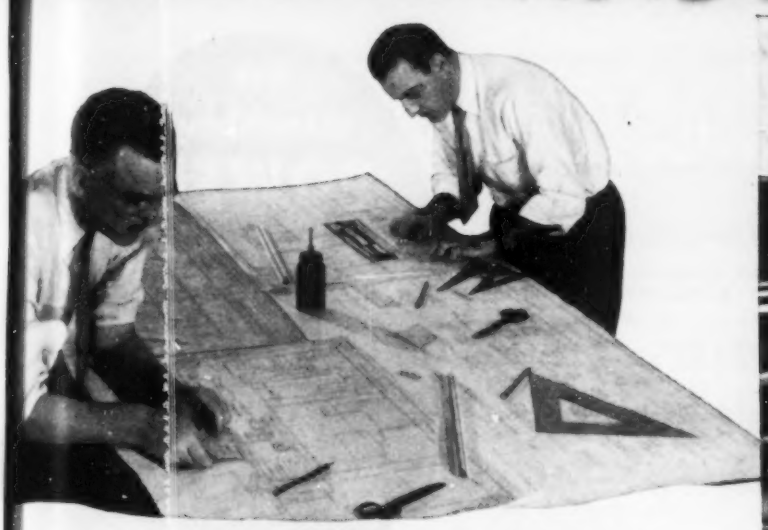
WESTERN COMPUTER CONFERENCE—First Meeting, Hotel Statler, Los Angeles, Calif.

March 16-20

NATIONAL ASSOCIATION OF CORROSION ENGINEERS—1953 Conference and Exhibition, Sherman Hotel, Chicago, Ill.

March 23-27

AMERICAN SOCIETY FOR METALS—Western Metal Congress and Exposition—Pan-Pacific Auditorium, Los Angeles, Calif.



The American Brass Company, Waterbury, Conn., reports

Plant layout speeded

with Kodagraph Autopositive Paper

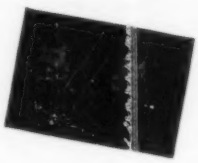
THE engineering and drawing reproduction departments of The American Brass Company must keep pace with the constant plant-layout demands of ten manufacturing divisions. *And here's how Autopositive Paper saves time and dollars in this work.*

First, paper cutouts of machines and equipment are pasted in position on a whiteprint of the proposed layout. From this opaque pasteup, a positive reproduction on Autopositive Paper is made *directly*. There's no negative step, no darkroom handling with this revolutionary photographic intermediate material. Just exposure in a standard whiteprint machine . . . processing in standard photographic solutions.

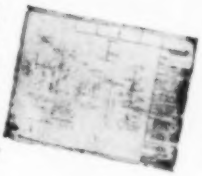
Then, the Autopositive intermediate—with dense photographic black lines on a durable, evenly translucent base—is used to produce the desired number of prints. These are sent to the branch involved to be studied and returned with comments.

This procedure may be repeated half a dozen times until complete agreement is reached on the final layout. And *every time* revolutionary Autopositive Paper saves time and dollars!

Other important uses of Kodagraph Autopositive Paper at American Brass



. . . to reproduce the blueprints and direct-process prints which the various divisions receive from vendors. The Autopositive intermediates are then used to produce any number of shop prints.



. . . to reclaim old, soiled, or worn drawings. Autopositive Paper intensifies line details . . . drops out smudges, creases—delivers intermediates which produce clean whiteprints and blueprints.

. . . to speed print service to all departments. Autopositive reproduces production reports, parts lists, documents of every type. And opaque originals can be copied as readily as translucent ones.

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction

Learn how Kodagraph Autopositive Paper is simplifying routines in thousands of concerns. Write today for a free copy of "New Short Cuts and Savings" for interesting facts about companies you know . . . and a revolutionary new product *you should know.*

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EASTMAN KODAK COMPANY, Industrial Photographic Division, Rochester 4, N. Y.

Gentlemen: Please send me a free copy of your new illustrated booklet, "New Short Cuts and Savings."

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Sans, Souci

Ad Libbing by the Editor

Late one afternoon the telephone bell rang. At the other end of the line Big Frank was telling me that I should have dinner with him that night. That is the way Big Frank did his inviting. He sounded very depressed so I knew that something had happened. That night we had dinner together.

All during the meal I could sense that there was something on Big Frank's mind that he wanted to say. I also knew that if I waited long enough he would tell me. Obviously the main reason for his dinner invitation was to get a load off his mind. Finally as we were dawdling over the coffee, Big Frank looked at me with glowering eyes and said, "He called me an ignorant wop."

This statement came like a bolt out of the sky. I didn't even know whom Big Frank was talking about. I said, "Who said that?" Big Frank answered, "Charley".

Then I knew everything that had occurred. There had long been hard feelings between Charley and Big Frank. Big Frank used to get Charley so angry that Charley would finally end up blustering and the reason, as I will explain, was simple enough.

I could appreciate how Big Frank felt. His was a powerful personality, a dominant one. He was in the habit of having men do what he told them to do and he had no patience with stupidity. His was a tremendously keen mind. He could figure out the cause and effects. He could analyze the reasons for human decisions and actions. He was an uncanny judge of people. Often he would tell me what I was thinking about even though what I was thinking was not related to the subject of our conversation.

However, it was true that Big Frank had a meager education. He left school before he was twelve. He could read but not rapidly. His addition was always perfect but long and laborious. Big Frank knew that and he recognized it. He worked hard to overcome these handicaps. He had a tremendous thirst for knowledge and learned fast. But his formal education remained limited.

As I sat there looking at Big Frank I had to feel sorry for him. Here was a man in an enviable business position, possessed of wealth, a man who had many friends in spite of brusqueness and a man whose council was sought

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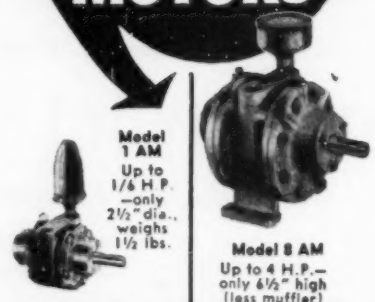

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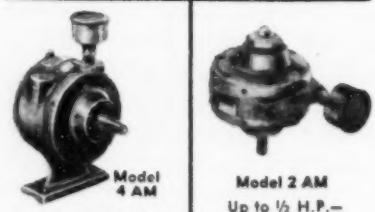

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by many financiers. As I sat there looking at Frank and thinking about Charley there came to mind an expression that Big Frank might use the next time he was put in the embarrassing position of being called an ignorant wop. So I said to him, "Mister, the next time anybody says anything like that to you just look him straight in the eye and tell him, 'I want to tell you something.' Then wait until all of the others in the crowd are looking at you and waiting to hear what you have to say to him. When you have everybodies' attention just say to the fellow, 'Obviously you are not sufficiently educated to be able to understand the difference between knowledge and intelligence. If you had some of the latter you would not have made that remark.'"

Big Frank sat there staring at me, gradually soaking in the significance of this statement. Then his face became wreathed in a huge smile and he said, "George, write that down, I want to memorize it." I don't know whether Big Frank ever used that statement. I hope he never had the occasion to do so. But I do know that Frank memorized that sentence because many times he laughingly quoted it back to me.

One of the human frailties is to judge others on what you have and they don't have. We fail to recognize the values in others and we magnify our own. There is a tremendous difference between education and intelligence. Unfortunately, the two do not always go hand in hand. And of even greater misfortune is the fact that a person will be given university degrees and academic honors for what he knows but there are no equivalent honors bestowed upon a person for his possession of intelligence.

Another one of my friends, also a man of intelligence far above average, was Fred the general superintendent. Fred was quite a different man. He was not only a college graduate but he became a college professor. But his greatest ability was not as a teacher, not as an educator, but as a manager of men. He was one of those men who have the uncanny ability to make his subordinates like him and work for him. I have often noticed that men of that character are men who possess a great deal of human understanding.

As an example of Fred's handling of men, one day one of the boys in the pattern shop got his fingers tangled up in one of the machines and lost two of them. After several weeks absence from work, the man came back. Naturally, he wanted the old job back again. The personnel manager had other

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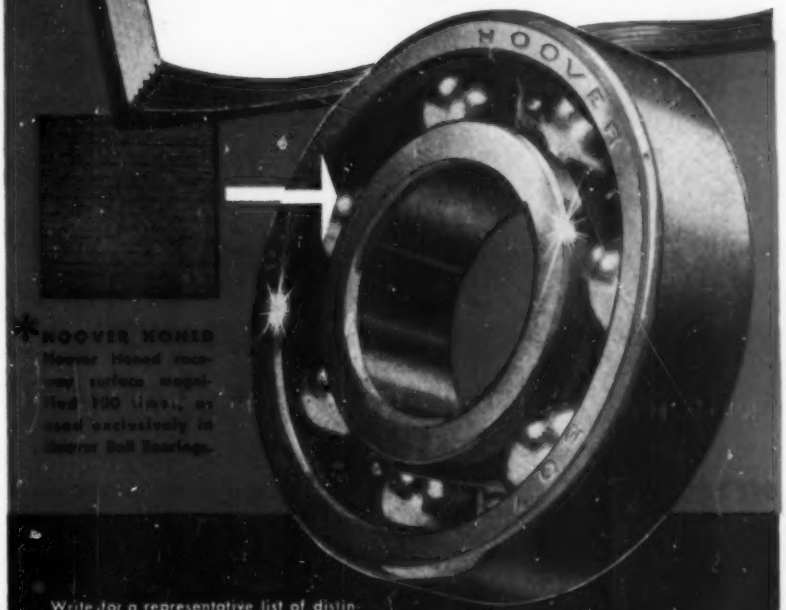

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Sans Souci.....continued

ideas. According to the personnel manager this fellow had proven that he was a very careless individual, that he was not to be trusted working with the dangerous machines in the pattern shop and therefore they would give the fellow the job of running the elevator in the No. 2 shop. That was the way the decision stood when superintendent Fred heard about it. He immediately called the personnel manager into his office and spoke to him. The conversation ran something like this:

"Sam is back again. I understand you are going to give him the job of running the elevator over in No. 2."

"That's right", said the personnel manager, "He has shown himself to be too careless to take a chance with him back in the pattern shop."

"Yes, that is one way of looking at it", answered Fred, "But there is another angle to it. Sam has lost a couple of fingers. Therefore the fingers that he has left are much more valuable to him. At least, that is how he undoubtedly feels about it. Another point is this, Sam is not only going to be extremely careful in the future but he is going to be a living example to the other boys in the pattern shop. They will all know that Sam has two fingers missing and they will also know how that came about. If Sam wants to go back into the pattern shop, there is where he should go."

That was about the end of the conversation. Sam went back to the pattern shop. He was a living example of what happens to careless men. The last I heard, Sam was still working in the pattern shop although by this time he is probably retired.

Of course, this does not mean that a manager should feel obligated to take another chance with a careless individual. The habitually careless man should be put in a job where he cannot harm himself or anybody else. This applies not only to men who are physically careless but also to those who are mentally careless in making calculations.

There is no harm in making mistakes if we recognize them before it is too late. Many great accomplishments are achieved by trial and error. But such mistakes are not in the same class as careless mistakes. The latter are dangerous, because they are hidden. Their existence is not known and therefore they might cause great harm.

You never know what it is that you don't know. That also applies to errors. If we know the error exists, we can take steps to correct it or compensate for it. But the careless mistakes are usually hidden until they come out of their hibernation to do their dirty work. —G. F. N.

ENGINEERING ABSTRACTS

Designing Magnesium Castings and Forgings

Abstracted from "Designing Magnesium Castings and Forgings" by George L. Moore, Chief Design Engineer, Cleveland Development Div., Aluminum Co. of America, *Modern Metals*, September 1952.

DESIGNERS HAVE THREE PRINCIPAL RESPONSIBILITIES that influence the serviceability of magnesium alloy castings and forgings. These are: Choice of the manufacturing process; alloy and its heat treatment, if any; and dimensional details of the design.

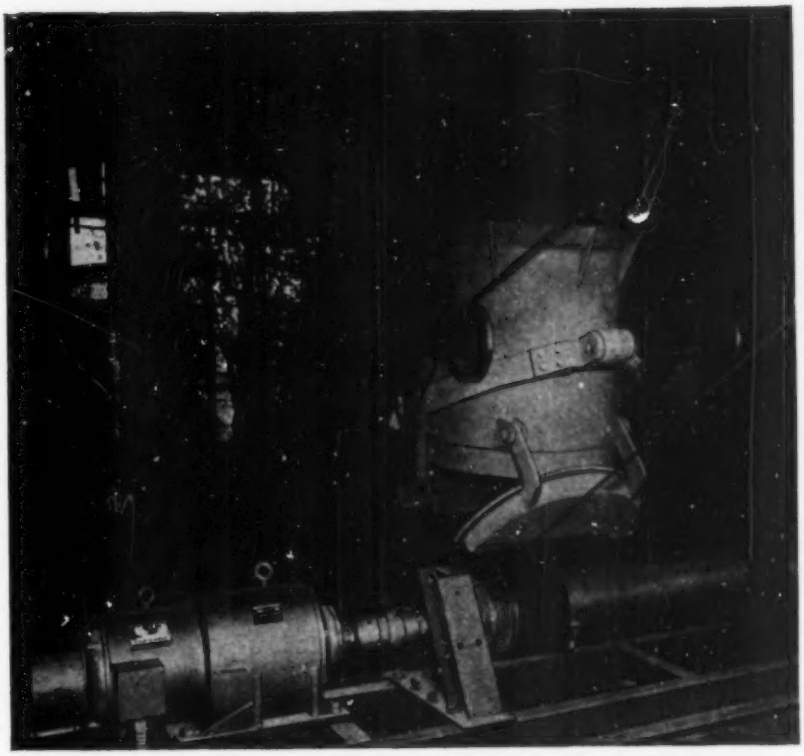
Choice of Process

The designer determines which manufacturing process is best—forging, sand casting, permanent or semi-permanent-mold casting, plaster process casting, or die casting. If the problem is one of rigidity, the process that will allow the largest moment of inertia with a given weight should be chosen. If the problem is impact, usually a forging is most attractive. And if strength in bending is a requirement, a casting may be superior because the metal may often be used more efficiently. If the problem is pure tension or compression, forging may be the answer.

Too often a manufacturing process is chosen on the basis of mechanical properties secured from test specimens, without adequate consideration of the probable design problems which will establish the most efficient use of the metal. It should not be assumed that a forging cannot be satisfactorily replaced by a casting having comparable weight. One of the advantages of a casting is that metal can be most efficiently placed.

On the other hand, it is often more economical to use a forging if the higher mechanical properties can be efficiently used. For example, a forging may cost $1.50 per lb, whereas the casting may cost $.75 per lb. If the allowable design stress factor for the cast design is 5,000 psi, whereas for the forging it is 10,000 psi, it would be no more costly to use the forging.

(In this comparison, it is assumed that the equipment costs are not a factor, but rather the cost to save a pound of weight. Where equipment costs are important, a sand casting can usually be designed to take the place



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of a forging, with a resulting sacrifice in weight saving.)

The choice of casting process depends upon the number of castings required, production equipment costs, and the amount of machine work. Sand castings require the most machining and usually require the smallest equipment charges. Die castings require a minimum amount of machine work, but equipment costs are usually the greatest. The equipment costs for permanent-mold, semi-permanent-mold, and plaster castings usually fall between those for sand castings and die castings.

Alloy and Heat Treatment

Maximum elongation and resistance to impact can usually be secured in magnesium castings by a solution heat treatment. Since most alloys which have received a solution treatment will age-harden at room temperature or slightly higher, it is important that the operating temperature be known, as any aging will reduce elongation and increase yield and tensile properties.

Operating conditions above room temperature can radically change the properties of an improperly heat treated alloy. For example, cast or forged parts may be given a 20 hr artificial aging treatment at 350 F following the solution treatment. But after prolonged service, the temperature to which the part has been subjected may produce sufficient additional aging to further increase yield strength and perhaps decrease elongation. Prolonged exposure to elevated temperatures will result in "over aging", with a loss in yield strength.

If distortion difficulties arise during machining, it may be necessary to use a stabilizing or strain relief treatment at some point in the machining operation. Such an operation will almost always change the heat treated properties. It would be more economical to have the forgings or castings properly stabilized initially, even at a sacrifice in physical properties.

Choice of alloy based on casting or forging characteristics cannot be overemphasized. Stress calculations, stress coat, strain gages and other tools will be of little value if the alloy will not produce a satisfactory part; i.e., one which meets a recognized standard of quality and can be regularly produced in the foundry or forge shop with a minimum number of rejects.

From the standpoint of design, ribs are correctly used only to improve section modulus or to serve as stiffeners and reinforcing members. When thin ribs are used to give added strength to a part, stresses causing rib failure

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may be transferred to the ribs from other sections of the part. For example, in an effort to save weight, deep thin ribs are frequently designed into the boss and wall as shown in Fig. 1.

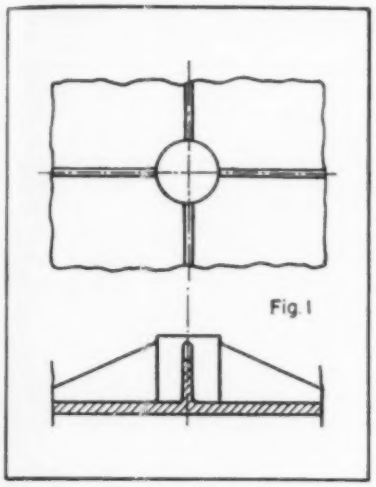

FIG. 1—Deep, thin ribs as shown above should be avoided.

As a result, certain foundry problems such as tendency for shrinkage, and cracking of rib edges may cause failure of ribs in service. In the case of forgings, the thin ribs may be difficult to fill and may be too highly stressed in service. High thin ribs are not generally accepted, except in die castings where an adequte number of thin ribs may be superior to thick ribs because of improved casting soundness. Even then, the ribs must not be highly stressed in tension. Almost always improved service will result by using a broad flat edge rib, as illustrated in Fig. 2.

In this example, design is improved materially by adequate blending, broader ribs, and reduction in rib

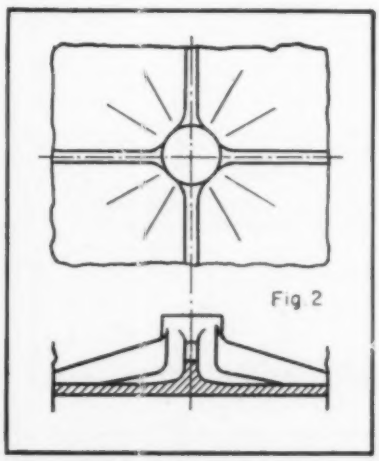

FIG. 2—A broad, flat rib is easier to produce and will give better service.

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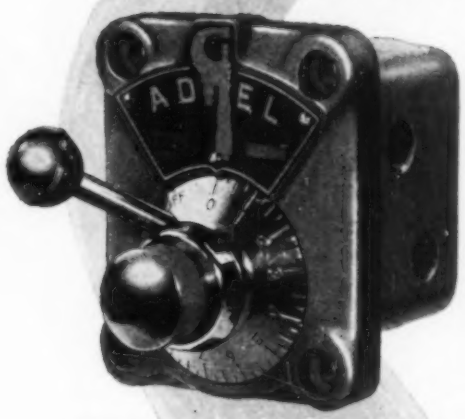

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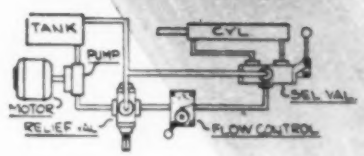

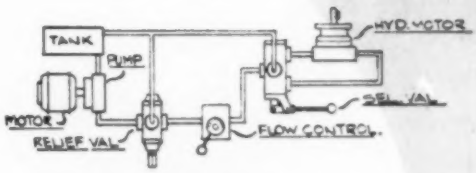

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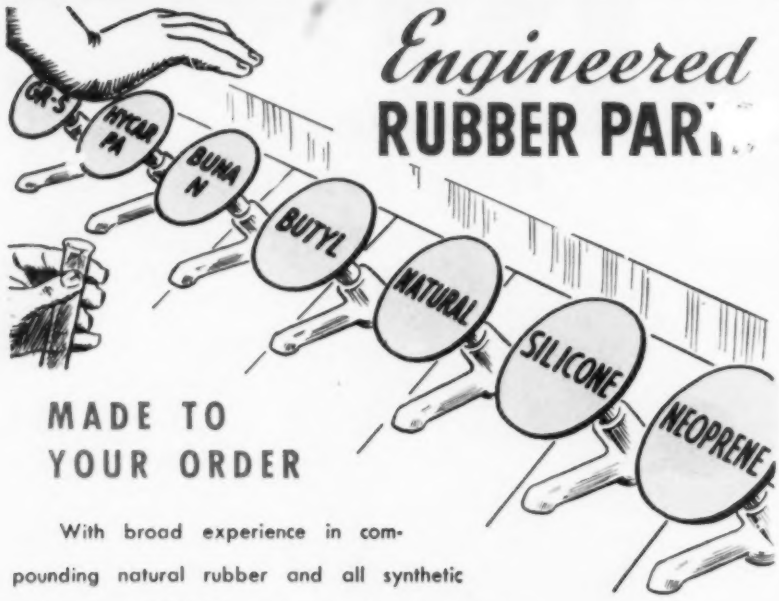

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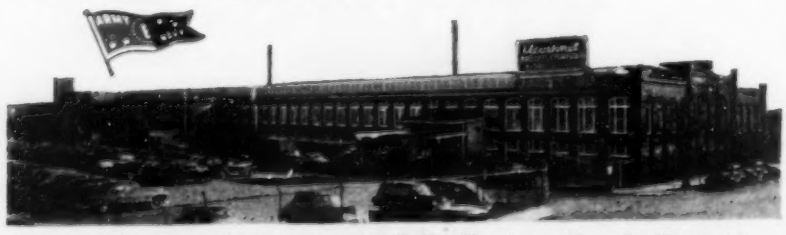

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height. Properly designed ribs improve the strength of a casting only when the design lends itself to the use of ribs, and when they are so proportioned that relatively low stresses will be carried through them. The addition of beads to the outer edges will reduce fiber stresses and improve strength. If practical, castings should be designed so that the ribs are molded in the bottom part of the mold.

It is almost impossible to design for an even distribution of metal which will allow walls and ribs to carry proportionate tension loads. Broad, wide ribs which will carry the entire load are desirable where rigidity is required. Where tensile strength alone is the object, a wall without ribs is best if the load is distributed uniformly into the wall. A study of the bearing supports of any well designed aircraft engine will illustrate highly desirable construction.

Fig. 3 illustrates the most satisfactory methods of joining walls to obtain improved foundry characteristics and more uniform stress distribution. The details of the heavy rib shown illustrates a satisfactory method of improving design from a stress standpoint. Such designs also will help eliminate cracked ribs and mis-runs when the part is cast.

The designing of flanges and bosses into the walls of a casting is shown in Fig. 4. Blending of heavy bosses into thin casting walls or forgings provides improved casting and forging characteristics, and lessens stress concentration. These methods of blending metal around bolt bosses, and recommendations for flange and bolt hole proportions, conform with foundry and forging practices that will produce quality

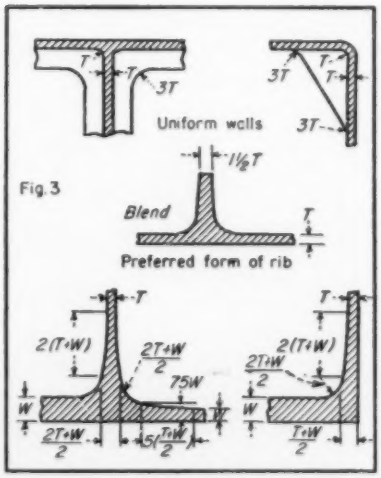

Fig. 3

FIG. 3—The most satisfactory methods of joining walls to get good foundry characteristics and uniform stress distribution.

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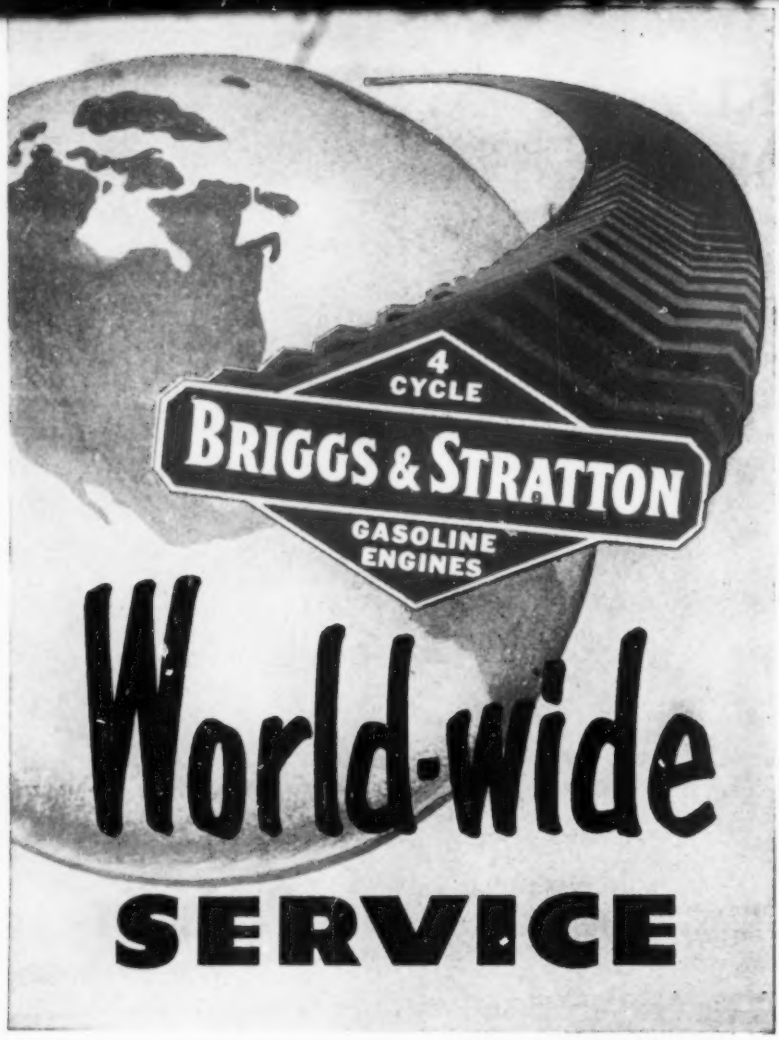

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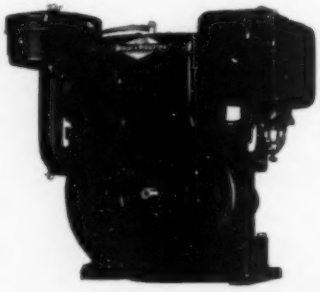

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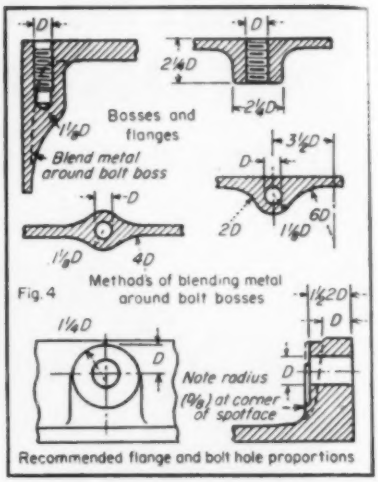

FIG. 4—Some recommended principles in the design of flanges and bosses into the walls of a casting.

parts. Necessary draft requirements for the process must be incorporated.

Fatigue Resistance

When designing magnesium castings to resist fatigue, a design factor equal to 40 to 50 percent of the recognized endurance limit of individually cast test specimens will usually suffice. If the expected service requirement is less than 500,000,000 cycles, fatigue strength should be determined for the expected number of cycles.

The design factor will also depend on nature of service—whether failure involves personal safety, whether part is expendable, etc. Knowing the life expectancy of a part and nature of service, and choosing the design factor accordingly will produce the lightest possible part.

The stress concentration factor should be given careful consideration. In a certain design, the calculated and actual stresses may closely approach each other—whereas the same part probably could have been designed by use of thin ribs, sharp changes in sections, sharp interior corners, or other forms of stress raisers which could easily double or triple the calculated stress. It is most difficult to establish the influence of these stress raisers, but they are to be avoided.

Creep Factors

Magnesium alloys serve well where a constant load on the part may produce creep. While the character of creep is not completely understood, it is considered safe to use a design factor of ⅓ to ½ the yield strength of the alloy.

Alloys best suited for applications where creep may be present (cooling

These sturdy sign supports were made from

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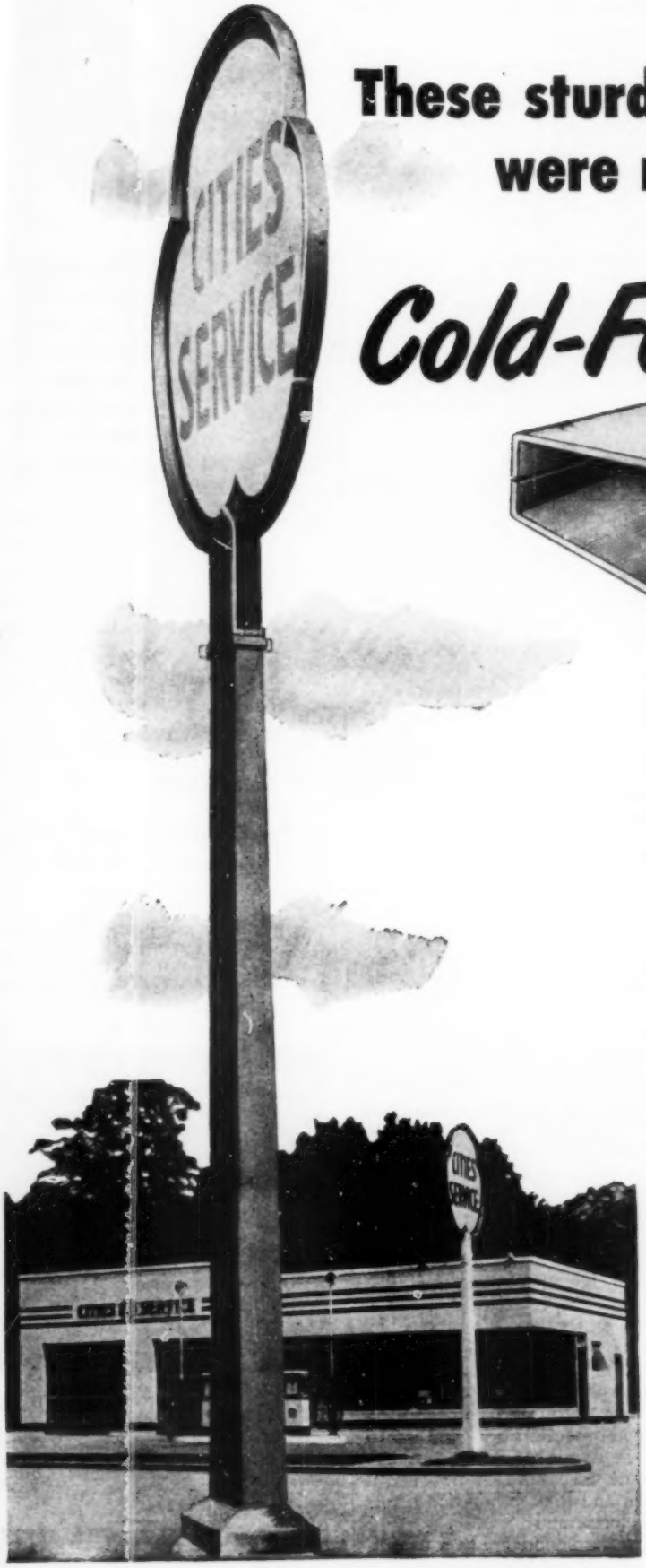

Strong, attractive signs used by Cities Service have pedestal poles made from Bethlehem Cold-Formed Shapes.

In making these pedestal poles we cold-formed tapered channels from rugged 10-gage sheets, then machine-welded two channels together, forming the rectangular pole. In addition, we provide the base, with holes for anchor bolts, and the base cover.

Poles for gasoline station signs are only one example of the growing variety of parts and products made from Bethlehem Cold-Formed Shapes. Lately we've formed, and in some instances fabricated, shapes for such diverse uses as door tracks, radiant baseboard sections, storage racks, and hatch covers for seagoing vessels. Manufacturers in widely separated fields often come up with ideas for new applications.

Bethlehem Cold-Formed Shapes are regular or irregular shapes formed cold from strip, sheet or plate steel. They are uniform in thickness, with a surface relatively free from scale. They have a high strength-to-weight ratio. We make them on presses, brakes or rolls in all gages from 5 to 24.

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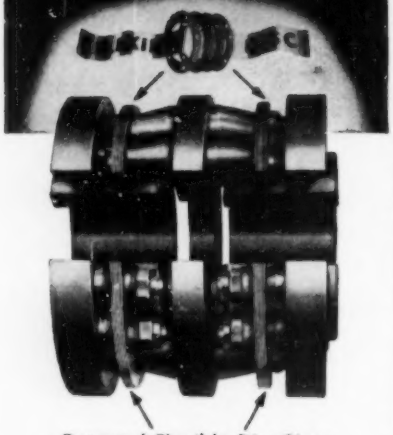

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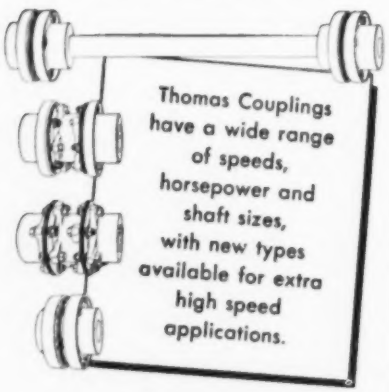

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fans and other highly stressed rotating parts) have the highest possible yield strength coupled with a small but definite elongation (3 percent maximum). Some ductility is particularly important where the casting is complicated, and relief of stress concentration is possible. More simple and very highly stressed castings should be made from alloys having lower ductility, as ductility at operating temperatures adversely influences creep resistance.

Rotating parts should be designed to burst at a rotating speed at least twice the operating speed. While rotating parts have been used as an example, it is possible to have creep as a result of any continuous load that stresses the part above the creep strength of the material. In most types of service, some sort of dynamic loading is present, in which case fatigue life must be given primary consideration—creep becoming secondary.

In the design of light metal parts subjected to impact loads, forgings should at all times be singled out as the best product to use. It will usually be found that maximum weight saving at the lowest possible cost results when a forging is used, as the safe design stress factor may be as much as twice the factor used for castings. In many cases, however, it is impractical or impossible to use a forging, and a cast design must be prepared with probably some sacrifice in weight saving.

When a casting is designed for impact applications, a safety factor as high as 10 or 15 on the basis of separately cast test bar tensile properties may be required. The alloy should have good ductility that will not be reduced by service temperatures.

Germanium Transistors

Abstracted from Germanium Transistors, by Dr. John S. Saby, General Electric Review, 1952.

A NEW FIELD OF ELECTRONICS is being created by the transistor, a three-element control device that uses a small current to control a larger one. Unlike vacuum tubes, transistors require no heated filament for their operation. They're extremely small in size and can operate effectively using power supply voltages as low as a few tenths of a volt.

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MODEL PM1
for soldering small metal parts and assemblies

SPEEDS UP PRODUCTION
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The Marion Model PM1 Induction Heating Units, pictured above, are in service at the Clyde, New York, plant of the General Electric Company.

Germanium diodes, diffused junction rectifiers and transistors are manufactured at the Clyde plant and the Model PM1 Induction Heater plays an important role in a sub-assembly operation on the whisker diode line. A very small pellet of germanium metal is soldered to the end of a nickel pin and the Induction Heater is used to elevate the temperature to the desired value.

This Marion low cost, low powered, portable Induction Soldering Unit (Model PM1) simplifies, improves and speeds up the production of magnet assemblies, relay armatures, connectors, capacitors, transformer cans, germanium diode assemblies and other parts and assemblies in the manufacture of electrical and electronic components. In addition, the Marion PM1 Induction Soldering Unit has many applications in other fields such as jewelry, watches, toys, automotive parts, household fixtures, etc. Wherever the application of intense heat to small units is required chances are that it can be done better, faster and easier with this Marion Unit.

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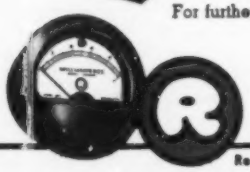

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ature effects is conduction caused by impurities in germanium. Atoms with five valence electrons—such as phosphorous, arsenic, and antimony—can enter the crystal-lattice in place of germanium atoms. Here four of the five electrons will enter the interatomic bonds, the fifth electron being bound by only the slight electric charge on the nucleus. At room temperature, thermal agitation is sufficient to free these extra electrons so that they can wander through the lattice and conduct electricity. This is called N-type conduction (N for negative). Because they provide conduction electrons, the impurities are called donors.

On the other hand, atoms with only three valence electrons—such as boron, aluminum, gallium, and indium—can also enter the lattice. Around each of these the structure will be locally incomplete, forming a trap for one more electron. An electron from a nearby bond can then jump into this trap, leaving a vacancy, or hole, behind. Still another electron can migrate into the resulting vacancy, and so on with the process. By actual migration of electrons, the hole effectively wanders about the lattice and in so doing conducts electricity. This is called P-type conduction (P for positive) because the holes behave like positive charges (their apparent motion is in a direction opposite to that of the electrons). Impurities that can trap electrons are called acceptors.

P-N Junction

When conduction is principally by electrons, a semiconductor is called N type; when it's principally by holes, it is called P type. However, N type and P type can and do occur in the same crystal. If they do, the junction between the N type and P type is called a P-N junction.

A P-N junction Fig 1 has a rectifier property in that an electric current flows through it in one direction with ease—but only with great difficulty in the other direction.

If the P region is made positive and the N region negative, holes and electrons are driven toward each other and

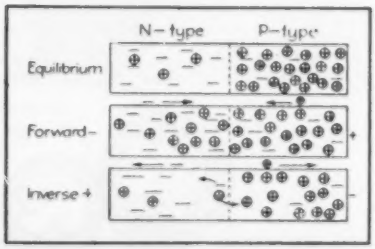

FIG. 1—P-N junction in germanium crystal is a rectifier.

recombine, each electron filling up one hole. The voltage need be only enough to keep this current going. This is the easy-flow, or forward, direction. If the P-type region is rich in acceptors while the N-type region has relatively few donors (so that there are few conduction electrons), most of the current crossing the junction is in the form of holes injected into the N-type region.

If we next connect the junction in the opposite, or inverse polarity, the electrons and holes move away from each other. The region close to the junction has its conduction electrons and holes removed, thereby becoming an insulator. Such a region is called the barrier layer.

An inversely biased P-N junction however will conduct electricity in the inverse direction if carriers are introduced. One way to do this is to heat the germanium so that bonds are thermally broken, supplying conduction electrons and holes. Another method is to shine light on the P-N junction—the light quanta releasing conduction electrons and holes.

Transistor Operation

Increasing the current through the barrier layer of a P-N junction can be accomplished by injecting carriers Fig 2A through another nearby P-N junction. Here there are two P-type regions separated by an N-type region, resulting in two P-N junctions arranged back to back. If the right-hand junction, or collector, is biased with inverse polarity, then little current flows through the barrier region into the collector. At the same time, passing current through the lefthand junction, or emitter, in the forward direction causes holes to be injected into the N-type base region. Some of them will recombine with the available electrons, but many will diffuse across the base region and into the barrier layer. The barrier layer ceases to be an insulator, and current flows as the positive holes are attracted toward the negatively biased collector. A change in emitter current produces a change in the collector current.

A transistor of this type is called a

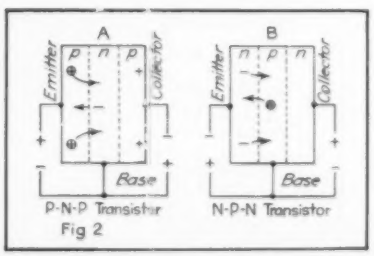

FIG. 2—Transistor comprises two adjacent P-N junctions.

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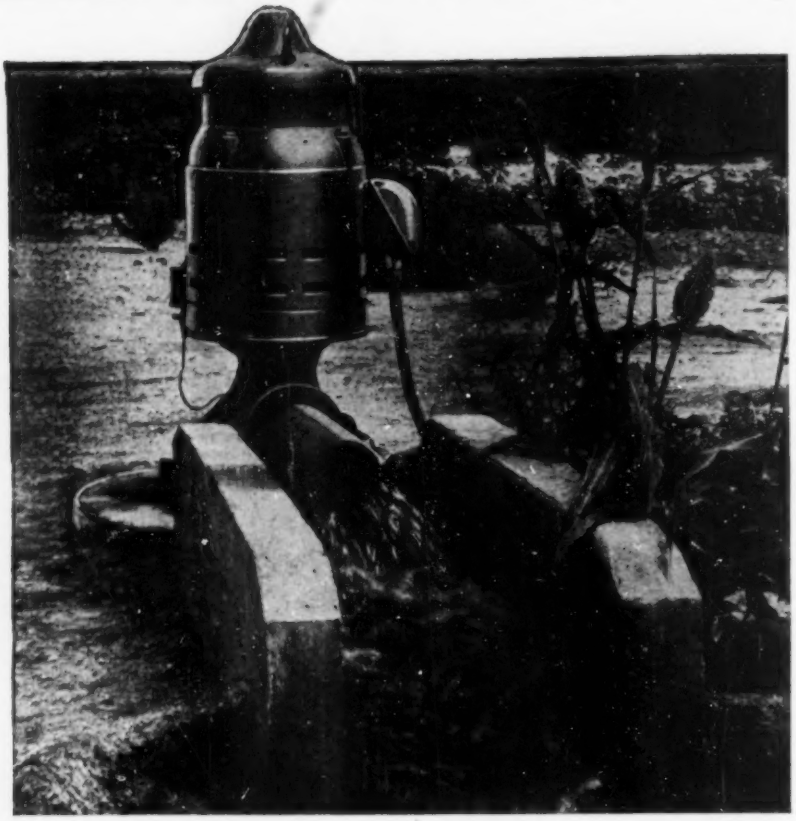

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P-N-P transistor because of the order of the ingredients in its germanium sandwich. The so-called N-P-N transistor works in an analogous manner as shown by Fig. 2B. Here you'll note that the bias polarities are reversed. The N-P-N emitter injects electrons that travel through the P-type base and are collected by the positively biased collector.

Junction vs Point Contact

In both the junction and point-type transistors Fig. 3, the emitter injects holes into an N-type base; and in both cases, holes are collected by a negatively biased collector. The point-contact transistor usually collects more holes than were emitted, however. It has a physical multiplying mechanism resulting in current amplification. Although this sort of amplification is an advantage in switching-circuits, such as used in computers, it often leads to instability in amplifier circuits of the hearing-aid variety. At present, point-contact devices are usable at higher frequencies than junction devices. They're noisier than the junction transistor however, and are limited to uses requiring relatively small currents.

High current gain can be achieved in a junction transistor if the current amplification factor alpha is close to unity, as shown in Fig. 4. The base current is small, and to apply the signal to the transistor it is connected as shown. Characteristics of this transistor (alpha is 0.95) are identical to those of Fig. 3. But by using the grounded-emitter connection shown, a current amplification of 19 is attained

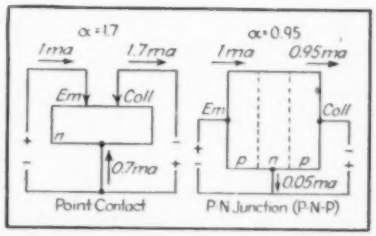

FIG. 3—Comparison of two kinds of transistor operation.

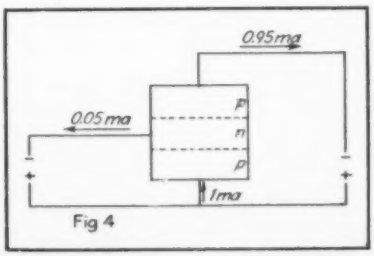

FIG. 4—Junction transistor utilizes small base current.

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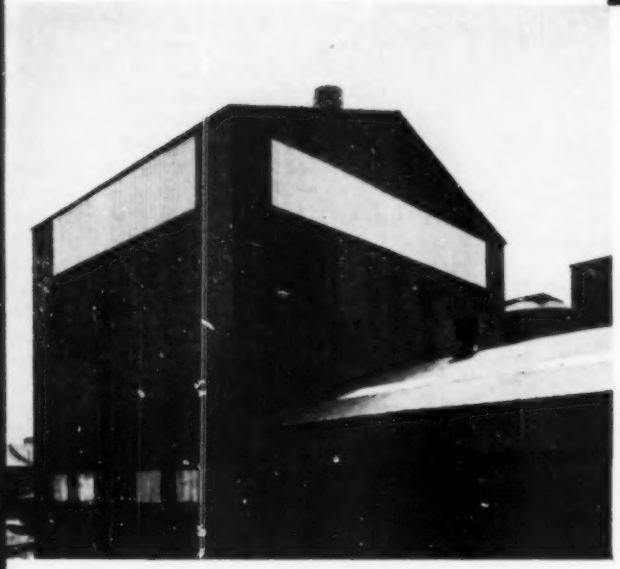

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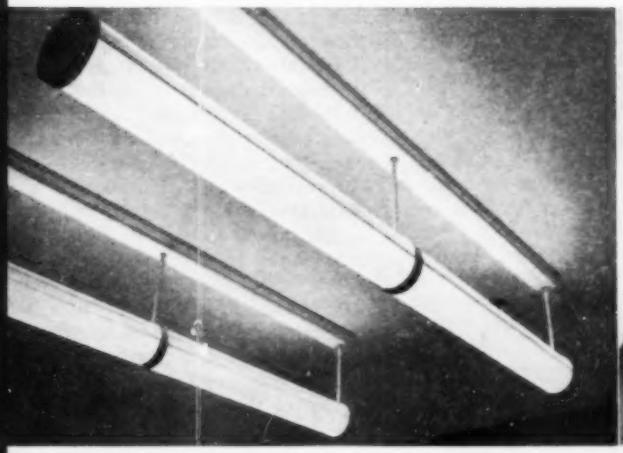
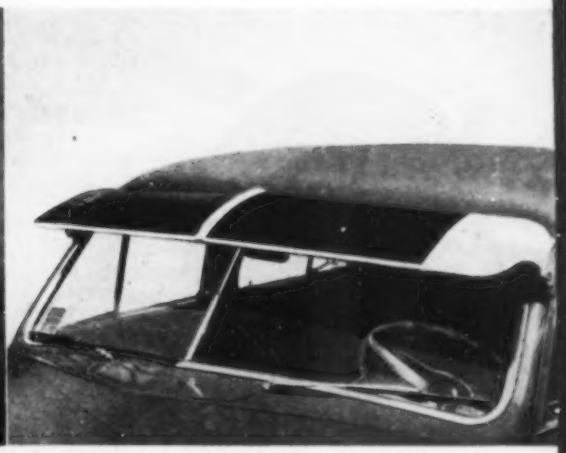


Totally enclosed lighting fixtures with extruded clear and white translucent PLEXIGLAS semicylinders.



Automobile sun visor with extruded green PLEXIGLAS sections, ribbed on upper surfaces.

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with the same voltage gain as before. If alpha is 0.99 the current amplification becomes 99. Obviously, then, values of alpha close to unity are desirable.

Diffused Junction

Production of transistors always depends on the formation of P-N junctions. In one new process two P-N junctions are created back to back on opposite faces of a single crystal-slab of germanium, resulting in a P-N-P or N-P-N sandwich comprising a diffused junction transistor.

For many electronic applications such as the tiny pulses required to transfer information within a computer, or the preliminary amplifier circuits of a radio, the useful signal power may be of the order of microwatts. On the other hand, a vacuum tube can't effectively amplify unless it is consuming a few milliwatts from its plate power supply. In addition, from 20 milliwatts to several watts are required to heat its filaments. Yet, the junction transistor actually operates efficiently with a power supply that provides only a few microamperes of current at a few tenths of a volt—literally a flea-power requirement!

Reliability

An electronic circuit originally in good operating condition will remain usable only until the first part fails. The greater the number of parts, the shorter the interval between failures. Reliability of the system as a whole is therefore poorer than that of its individual components: and becomes progressively poorer as the number of components increases.

Transistors are not limited to operation at low power levels. Successful higher-powered operation at the audio frequencies is achieved with internal power dissipation of several watts. There's no theoretical upper limit to the power level that transistors can hope to reach, but there are practical considerations to contend with.

One of these concerns the behavior of junctions at high temperatures, where the holes and electrons liberated by thermal agitation cause large currents to flow that aren't subject to control by the emitter. This thermal leakage current in turn produces more heat that must be removed. Power transistors must therefore be cooled, and the effectiveness of the cooling system sets a practical limitation upon the upper limit of the power level. For example, a junction transistor that would safely dissipate one-half watt in the open air at room temperature could be operated at one watt is air-

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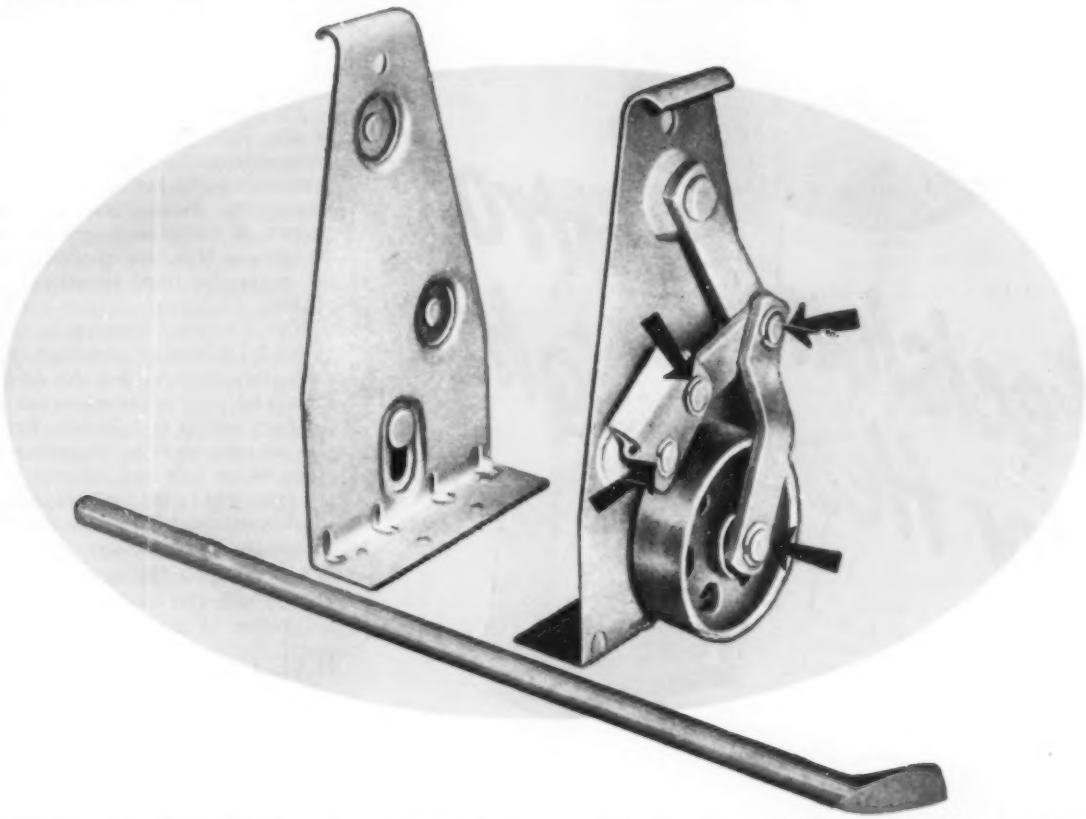

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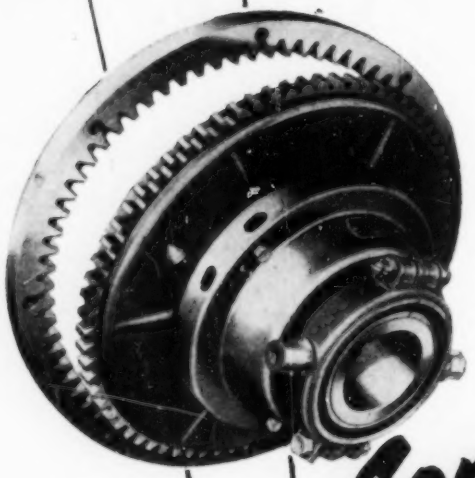
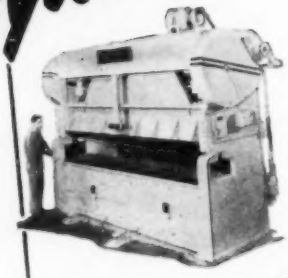


Precision Control for Heavyweights

When the Cyril J. Bath Company of Cleveland, Ohio, developed the new PT series Power Brake to accommodate end-feeding as well as side-feeding, they needed a clutch and brake unit which would permit continuous or single cycle—and would also "inch" the slide during setup.

Like most leading manufacturers of metal working machinery, Bath turned to Twin Disc for the solution. Twin Disc field engineers recommended two CL-311 Clutches . . . units from the standard Twin Disc line proved satisfactory. Today, the big Bath PT Brake is accepted by industry as a highly successful dependable production design.



New Bath PT series Power Brake, equipped with two Twin Disc CL-311 Clutches. Said R. M. Humiston, Bath V. P.: "Twin Disc clutches were selected because they provide positive control and trouble-free performance."

Whether you are designing new-type machinery or redesigning present models—Twin Disc can probably supply your power linkage needs with job-proved Friction or Hydraulic Drives *from the standard Twin Disc line.* Why not write today for complete information or design help?

Built for a Long Life . . .
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CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

cooled—and perhaps five watts if cooled by running water. On the other hand, if it were imbedded in a large block of plastic, it might only operate safely at approximately one-half of its open-air rating. It now becomes apparent that the power transistor must be packaged in a form large enough to dissipate its rated power—and the final package may be much larger than the transistor itself.

Frequency Response

The junction transistor has full gain at the audio frequencies but in its present state of development can operate with usable gain as high as a few megacycles. Point-contact transistors operate at frequencies approximately 10 times as high, and operation above 50 megacycles is occasionally accomplished.

High-frequency response is a complicated function of collector capacitance, transit times, and the diffusion process whereby minority carriers wander from emitter to collector. Transistors are now operating in a frequency range where each new increase in the top frequency opens new applications. It's therefore understandable that high-frequency effects occupy an important position in the agenda for further research.

HAE Coatings

Abstracted from "Getting the Most from HAE Coatings," by M. Frager and H. A. Evangelides, Chemical Engineers, Frankford Arsenal, Philadelphia, *Metal Progress,* September 1952.

The HAE process electrolytically produces on magnesium or magnesium alloy surfaces a nonmetallic coating typically one to two mils thick (0.001 to 0.002 in.) that is both hard and very adherent. Its combination of properties, including freedom from porosity, resistance to heat, and chemical inertness, warrants its consideration where magnesium is selected for design purposes.

It is unusual that a material as hard and refractory as this coating should, at the same time, be as tough and elastic as—for example—a highly plasticized vinyl resin plastic.

Magnesium has not been used more widely because of its susceptibility to damage by corrosion. The HAE coating, because of the protection it provides will add significantly to the number of applications for this metal.

The HAE process provides electrolytically a coating which, if unsealed, enables wrought magnesium to withstand 20 percent salt spray exposures,

without any corrosion being visually detectable, as follows:

Alloy	Time to Failure
J—1 (6.5 percent Al, 0.15 Mn, 0.95 Zn)	90 hr
FS—1 (3 percent Al, 0.20 Mn, 1.0 Zn)	26
M (1.20 percent Mn)	Several

It is interesting to know that although there may be a few very small corrosion spots present at the time of initial failure, a continued exposure for several times the hours to failure does not increase their number. This indicates a certain amount of minimum porosity (some of which may be attributable to a lack of homogeneity in the surface of the magnesium) and also indicates the chemical inertness of the coating.

In the evaluations conducted at the Pitman-Dunn Labs., the salt spray is used as a criterion of porosity for inert or cathodic coatings and as a measure of the weight per unit area of anodic metallic coatings. No exact correlation should be made as to the expected outdoor weathering resistance. However, since the coating functions primarily as a mechanical barrier, and the NaCl fog detects very fine porosity, there is good reason to expect long endurance for sealed HAE treated magnesium used in outdoor exposures.

It is known that use of a suitable rust-preventive oil over phosphated steel represents a sort of synergetic action. That is, the resistance to corrosion of steel which has been phosphated and oiled is far greater than of the expected mathematical total of steel that has been phosphated and steel that has been with a rust preventative. So, too, with the HAE process for magnesium. This surface protection, plus a suitable wax seal, will withstand and has withstood a salt spray exposure of more than 13,000 hr. Similarly, instead of wax, zinc chromate primer or a phenolic finish over the HAE surface will give excellent results. For those applications where protected magnesium may be used in gears, a high degree of corrosion resistance exists because of the sealing action of the lubricant at the few pores in the coating. In addition, silicone greases have been used successfully. With all of these methods, the effective work of sealing magnesium is done by minute amounts of sealant which close those few pores remaining in the HAE coating at the end of the process.

Dielectric strength of the coating at 60 cycles is about 550 v, with a coating

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(IN ANY SHAPE OR METAL)

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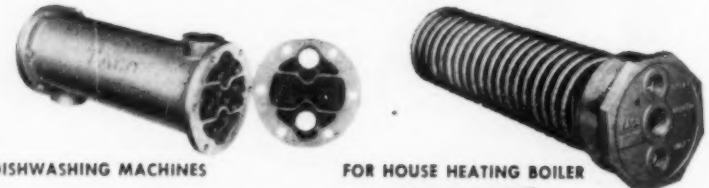
Whenever the product you're designing or manufacturing requires a shell and tube heat exchanger, discuss your space limitations and design requirements with Taco. You can be sure our solution will save you space, time and a lot of engineering headaches. We've been helping manufacturers who need special heat exchangers of different metals for many years.

Here are Two Examples of Special Taco Heat Exchangers Designed to Meet a Space and Capacity Problem



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thickness of no more than 2 mils. This insulation value indicates a highly nonconductive and impermeable coating. Since the insulating quality is so high, it obviously should serve as an effective means of preventing galvanic coupling action, the bane of magnesium structures assembled with other metals. However, there are definite precautions which must be observed in using magnesium coupled to another metal. These precautions are based on the fact that the hard, brittle nature of the coating, regardless of its impermeability requires proper techniques for effective assembly.

The magnesium to be HAE treated should be in its final form and fully machined; that is, not require any operation which will bend or deform it. Nor should the metal be cut, drilled or ground after the coating has been applied. If the magnesium has been stamped, feathered portions should be deburred so that the coating is not applied unnecessarily to fragments of magnesium which may break off readily and expose bear metal. The preferred sequence for the cleaning of castings is to sand-blast the surface of investment materials and then machine prior to the HAE treatment. This is better than submitting a machined casting to sand-blasting, a procedure likely to damage finished surfaces. No prior chemical treatment should be applied to castings.

Since the coating is relatively impermeable, any break in it will produce more intensified corrosion at the damaged area than if no coating at all were on the magnesium. For this reason it is definitely a poor practice to have HAE treated magnesium sheets drilled and riveted.

Ferrous metals and copper-bearing alloys used with magnesium should be cadmium plated or zinc plated, and the plating chromized and organically finished to minimize the amount of cathodic metal exposed in a couple with magnesium.

A good paint system for the HAE coating consists of one coat of the 3-201 primer and one or more top coats of JAN-E-480, Type I. The prime coat should be applied to a thickness of 0.4 to 0.7 mil, the top coats to a thickness of 0.7 to 1.2 mil. The excellent appearance of scribed specimens so prepared and exposed in the salt spray for 2,000 hr gave no reason to believe that the exposure could not be repeated for an equal length of time without failure.

The use of heat-reactive phenol formaldehyde varnishes complying with U. S. Army Specifications 3-221 has also been very successful, even with

C-D-F makes all three!

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Designers, engineers, production men everywhere are changing their thinking (and specifications) over to economical C-D-F spiral tubing. Whether it's round, square, or rectangular, C-D-F tubing is stiff, sturdy, crush resistant. It has good tensile strength, along with good dimensional stability under varying atmospheric conditions.

Above all, it is low in cost. C-D-F experts in insulation, recommend spiral tubing for coils and structural spacers. For transformers, switches, selenium rectifiers.

The round tubing ranges from ⅛" to 6", with wall thicknesses from .0075" to ⅛". The minimum ID of the square and rectangular tubing is ⅜", with 2⅛" the maximum ID. 1/16" is the maximum wall thickness. All tubing can be supplied in lengths from 2' to 4'. From our own fabricating experience, we know you will find this sturdy material easy to drill, tap, rivet, flute or thread.

Think it over . . . then talk to the man from C-D-F, a skilled plastics engineer. C-D-F has sales offices in principal cities with modern test laboratories at all plants. C-D-F spiral tubing. The man from C-D-F. *Both* are good to know!

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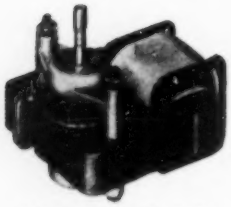
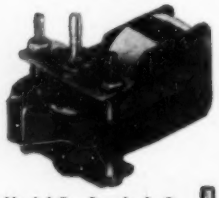


Model A—2-pole A.C. induction type

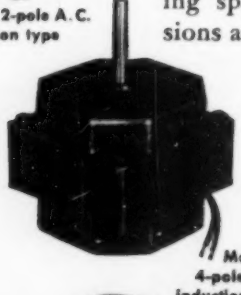
Compact size is but one of the plus characteristics that distinguish the famous GI line of *Smooth Power* small motors.



Model C—2-pole A.C. induction type

In countless applications—from advertising displays to ventilating fans—they provide the ideal combination of dependable performance and trouble-free long life to match even the most severe operating conditions.

Write today for detailed information, including specifications, design features, dimensions and quantity price quotations.



Model D 4-pole A.C. induction type

Model O 2-pole reversible capacitor type (for 6 or 12 or 24 volt A.C. only)

THE GENERAL INDUSTRIES CO.

DEPARTMENT MM • ELYRIA, OHIO

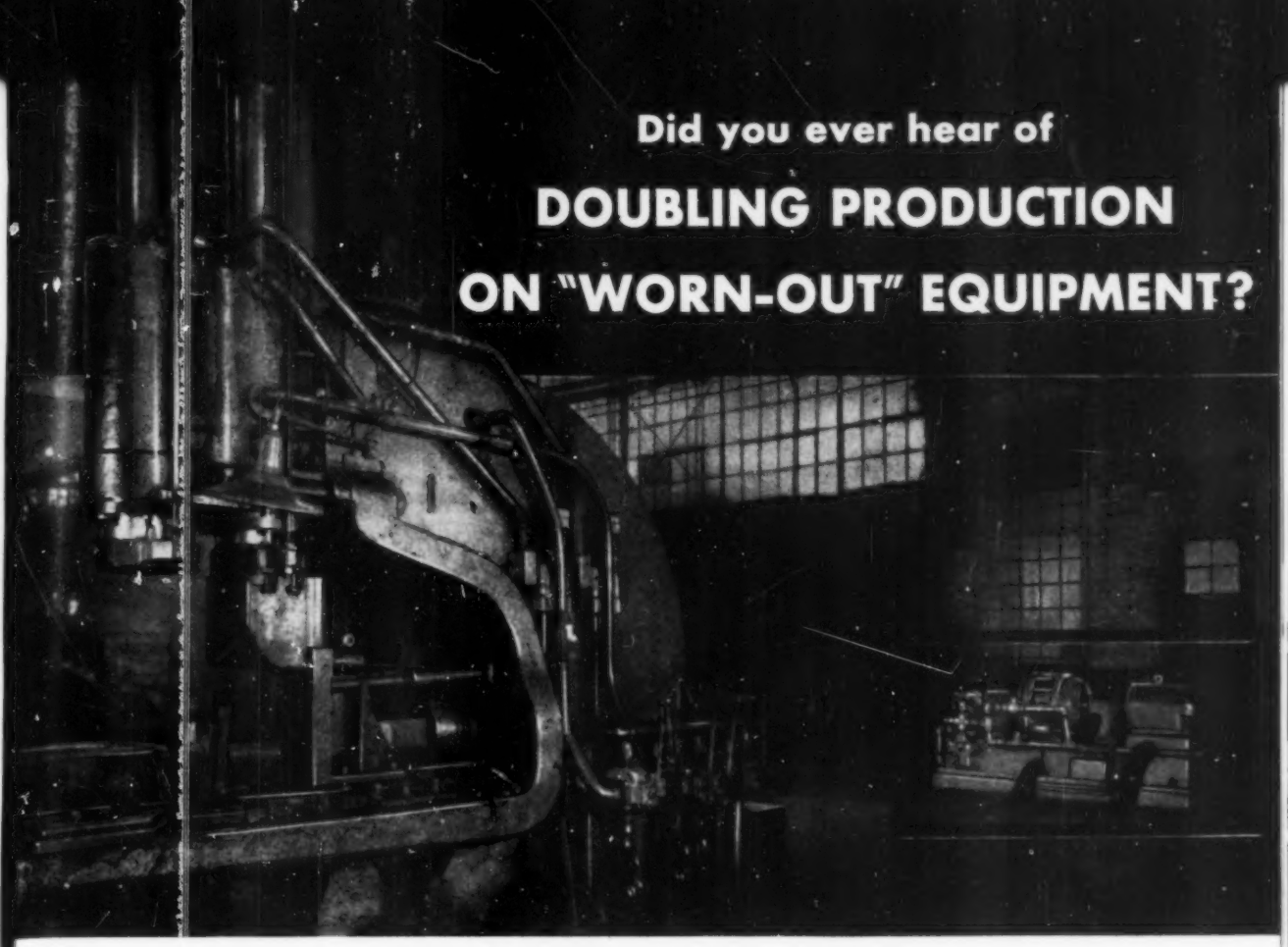
films so thin that dimensional changes cannot be determined with micrometer calibers. The normal thickness for such films is 0.4 to 0.6 mil. Other paints are now being studied.

Just as zinc phosphate films on steel and aluminum oxide films on aluminum have been very helpful in preventing welding of these metals with steel punches, and dies during drawing operations, so also the use of this coating may be beneficial for forming operations on magnesium.

In experiments at the Pitman-Dunn Labs., preliminary results on the bonding strength between HAE coating and the magnesium revealed that a force of at least 2,500 psi would have to be applied normal to the surface to separate the coating from the metal.

The hard, inelastic nature of the HAE coating and its strong bond to the magnesium indicate that its best performance, from the standpoint of protection against corrosion and wear, can be expected from applications to rigid surfaces and not to those which will be cut, ground or deformed after the coating has been applied. Furthermore, the hardness of the coating (sufficient to abrade steel of Rockwell C-65) suggests its possible value as an abrasive material with the abrasive already bonded to a surface, the geometry of which can be varied at will. The coating, in addition to acting as a dielectric material, may also be of interest for possible capacitor and rectifier applications. Because of its poor thermal conductivity, it may also permit magnesium to be used where heat is involved and where magnesium with ordinary treatments would be adversely affected.

Tests on fatigue strength conducted for Frankford Arsenal by the National Bureau of Standards show that with magnesium specimens 94 mils thick and with a coating of 1.5 mils, there is a loss in fatigue strength of about 8 percent which, if corrected for the thickness of the coating, amounts to 2 percent. With a 40 mil magnesium sheet, there is a reduction in fatigue strength of 17 percent which, if corrected for coating thickness, is only 4 percent. These results are higher than those obtained for specimens with lower HAE coating thicknesses. Although an appreciable part of the loss in fatigue strength is attributable to the etching action on the magnesium surface at the interface during the formation of the coating, the results show that the effect on fatigue is rapidly lowered as the metal thickness is increased and also that thinner HAE coatings may be desirable for applications involving repeated flexure.



Did you ever hear of DOUBLING PRODUCTION ON "WORN-OUT" EQUIPMENT?

You may gain a valuable hint from this story how Treadwell renovated an old belling machine with Oilgear Fluid Power

The belling machine used for flanging big boiler ends in the Treadwell Corporation plant at Midland, Pa., has seen many years of service. The machine was slow, was "down" a lot, maintenance was high and production was off.

A careful analysis indicated that the press itself was not at fault; the trouble was associated entirely with the water pump, storage and accumulator system used to power the press gripping and main rams.

Two alternatives confronted the Treadwell people. One was to repair or replace the water system. This ran into a figure prohibitively high. It would not solve the problem of high maintenance, faulty control, erratic performance, the shocks inherent in the system, the slow cycles.

The Treadwell people chose the second alternative and called in an Oilgear Fluid Power engineering representative. This is what happened:

A standard Oilgear Fluid Power system was installed, without modification to the press. The only change was some rearrangement of the piping system. The cost was from one-fourth to one-third that of repair to or replacement of the water power system.

The operation of the rams was speeded up, the total time for each cycle cut from 66 seconds to 34 seconds. Therefore actual press production was almost doubled. Because the power medium used is oil, friction and wear become almost non-existent. The space required is slightly less than that required by the water pump, but the bulky water tank and accumulator were eliminated altogether.

The interesting thing about this Oilgear Fluid Power, which is smooth, shockfree and dependable is that from the one source, power travels to actuate the gripping rams, then while holding them at gripping pressure, travels over to the main or shaping ram and actuates it; then the same power retracts the rams in order and goes into "neutral" during the next handling step.

The above is only one of a number of similar press "renovations" being performed with the use of Oilgear Fluid Power.

Think of Oilgear Fluid Power as similar in every respect to electric power. It is generated, piped, and applied in the same way, with these **important** exceptions: Oilgear Fluid Power can be used in linear movement where electricity cannot. Oilgear Fluid Power speed can be varied steplessly, smoothly, infinitely where electricity cannot — or only with costly, troublesome, **extra** equipment. Oilgear Fluid Power can be "bled" off, dissipated harmlessly in case of shock. Oilgear is massive, tremendous, resistless power that can be controlled with micrometer precision.

It is probably the most amazingly versatile power there is. Consider Oilgear Fluid Power to improve the saleability of new machines, to renovate old machines, to solve a hundred troublesome problems where other power has failed to help. It costs you nothing to find out. THE OILGEAR CO., 1571 W. Pierce St., Milwaukee 4, Wis.

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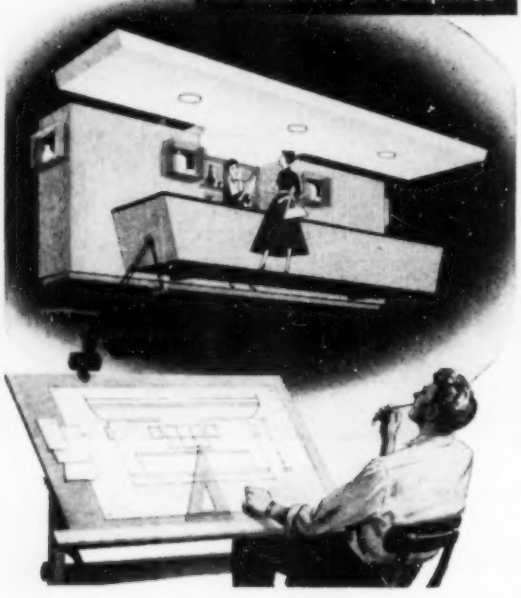

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Add this to plywood's many other advantages and you'll see why it is preferred for fixtures and furniture . . . paneling and cabinets . . . displays and partitions . . . siding and signs. No other building material does so many jobs so well.

For further information, write Douglas Fir Plywood Association, Dept. 4512, Tacoma 2, Washington.

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OUR READERS SAY

Spring Calculations

To The Editor:

In your June 1952 issue, on pages 155 and 156 are published two interesting charts for rapid calculation of helical springs made of rectangular bars. The problem involved may be divided in two parts: i.e. in calculating maximum working load P_m on the spring, and its deflection on basis of spring material previously specified; and in calculating dimensions of spring material to be used for a definite performance of the spring. The solution of the first problem does not represent any difficulties, particularly if the spring height is unlimited; however, selecting the size of spring material on the basis of maximum working load P_m initial steady load P_1 working deflection f, outside diameter of the spring D and its height L, in the preloading position will require many manipulations when using the charts in Fig. 2 and 3 comprising unknown values $\frac{b}{a}$ and $\frac{2r}{a}$ $\frac{D-a}{a}$

In the common practice, the designers of springs are obliged to consider this last case which limits the practical utilization of the charts. It is evident that with height L, non-specified and unlimited, rectangular spring material can be replaced by round, more cheaper material.

—VICTOR TATARINOV
Consulting Engineer
Pilsen, Czechoslovakia

Patent Difficulties Explained

To The Editor:

Mr. Charles P. Grimes' letter in PRODUCT ENGINEERING for October 1952 raises some interesting points in connection with patents. Perhaps it is somewhat out of place for a Canadian patent lawyer to comment on United States Patent Law, but our patent system is closely modeled on yours, and the new amendments which you have made bring our two patent systems even closer together.

The "Flash of Genius" has never been part of the patent law in this

country, and the United States has now rejected it as well. As I understand your amendments, however, I do not think that the standard of invention has been in any way reduced. It seems that it is still necessary to show in a patent application something which the public did not have already and which would have not been obvious to one skilled in the art.

Mr. Grimes wonders whether he could now make a fresh application. Based on the information which he gives in this letter, and assuming that the original application was abandoned, it seems that the prior use of the device which he described would now bar a fresh application.

Mr. Grimes mentions the manner in which the United States Patent Office digs up foreign patents showing similar structure. It seems to me quite proper that foreign patents and publications should be looked at, and I believe it is a tribute to the Examiners of the United States Patent Office that they are so efficient in finding the same.

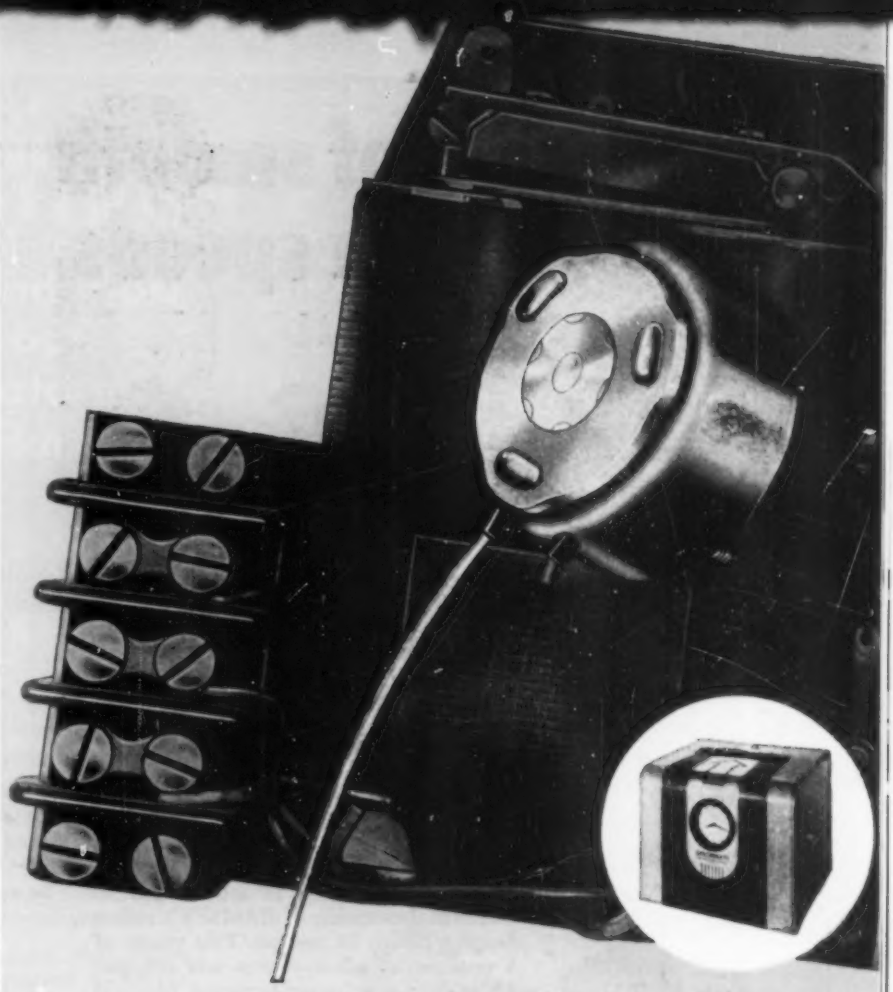
However, it often seems that Examiners both in this country and in the United States are unduly diligent in combining references and suggesting that all the inventor has done is to take part of a device shown in patent A, add to it another device shown in publication B, and further combine it with another structure shown in patent C, overlooking the point that there may be considerable invention in seeing how to combine such structures.

It may be going too far to say that the manufacturer in this case was unfair. Most of the difficulties in circumstances such as this arise from a failure of both the inventor and the manufacturer to work out in advance a full agreement on what the rights of both granted, and in the event that it is not. It may very well be of considerable value to a manufacturer to have "know-how" arising from an inventor's work, even if a patent is never obtained, but this should all be worked out in advance.

—WILLIAM R. MEREDITH
Barrister and Patent Attorney
Ottawa, Canada

To the Editor:

In your October, 1952, issue there is an letter from a Charles P. Grimes, setting forth a complaint about a certain manufacturer, un-named, who commenced some operations under some arrangement, whereby Grimes was to receive a payment for each article made and sold; however, it ap-



LEDEX ROTARY SOLENOIDS

. . . double efficiency and LOWER COST 70%
for The Cincinnati Time Recorder Company

The compact, powerful number five Ledex Rotary Solenoid is used to replace the bulky old type solenoid in the Cincinnati series 800, Automatic Time Recorder. By comparison Ledex Rotary Solenoids have 1/7 the weight . . . produce twice the power output with the same electrical input . . . proved to be more dependable and easier to install . . . *and reduced the cost of this component 70%*. The actual size illustration of the solenoids show the advantage of Ledex compactness . . . 1/6 the volume.

Let Ledex Engineers assist you in choosing rotary solenoids that will save production costs and help increase the efficiency of your products. Six basic models range in diameters from 1⅛" to 3⅜", with torque values from ¼ to 50 pound-inches. Various power linkages and types of mountings are available. Write today for descriptive literature.

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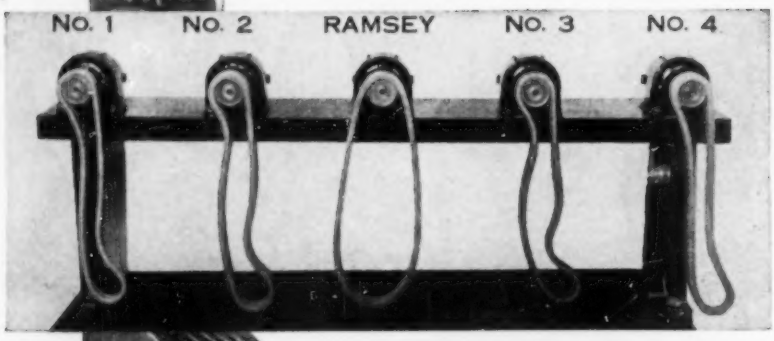
Here's proof of smooth power at high speeds



with RAMSEY SILENT CHAIN DRIVE

What you see above is an interesting demonstration of friction in action—*and* an excellent illustration of RAMSEY's roller-bearing design in motion. This photo of 5 commercial silent chains was snapped while they were spinning under identical conditions at 5800 R.P.M. The curious curves and convolutions of 4 of the chains are caused by *friction* generated *within* the joints . . . The RAMSEY chain shows the smooth, vibration-free characteristics permitted by its exclusive roller-bearing action between links. Two curved, case-hardened pins join the links—actually *roll* on each other as the chain flows around the sprockets. This practically frictionless action results in a whip-free drive—even at high speeds. For power-saving efficiency in your next mechanical drive application, specify RAMSEY Silent Chain.

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This 60 page book gives you the range and scope of Ramsey Silent Chain Drives — tells you how to work out applications and includes the necessary data on chains, sprockets and pinions. Write for a copy today.

SILENT CHAIN DRIVES — FLEXIBLE COUPLINGS

RAMSEY CHAIN COMPANY, INC.

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pears, now, that the manufacturer is no longer paying Grimes because of some patent difficulties.

Grimes did not state the nature of his agreement with this firm, nor did he say if there was a cancellation clause in the agreement permitting the manufacturer to cease payment if a patent did not mature from any applications for the patent that might have been pending, or filed prior to, or following the date of their agreement.

While I am not speaking as a lawyer in this instance, I do understand that under certain circumstances, where a manufacturer has accepted drawings, designs, and specifications for a product from another party, and later does not enter any agreement for the manufacture of the article, but does actually misappropriate these previously handled drawings, and manufactures without payments following or some agreement relative to said manufacture, such circumstances may permit the owner of the product, or who has in the first place submitted the drawings, to file suit. If the evidence warrants it, he may collect on the basis that the misappropriation was COMMON THEFT.

The controlling conditions in each instance will no doubt vary, but it might pay Mr. Grimes to go into this angle with a legal authority who knows patent law as well as civil phases. There possibly is reason to feel that this manufacturer was certain of his legal ground before he discontinued any payments. And it might be considered that any inventor, as prolific as Grimes apparently is from his record of patents set forth, should have, or now should do some fundamental study of the law surrounding patents and agreements.

—HARVEY A. PEARSE
Seattle, Washington

How Do You Make Nails?

To The Editor:

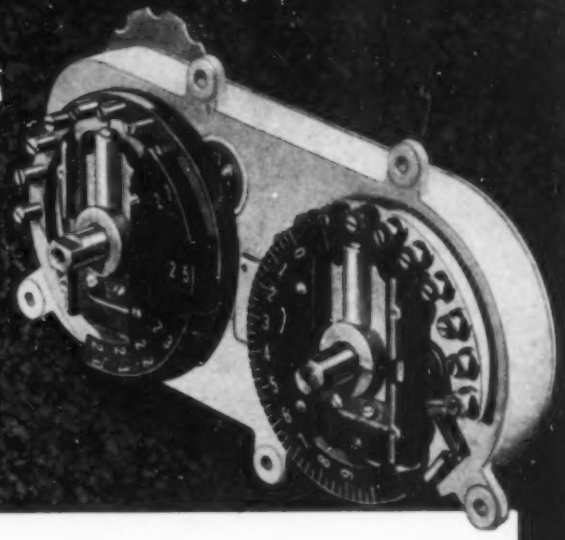
We are planning to start a Nail Factory here in Cebu, and we cannot get any complete information on the process of manufacturing nails. Would it be possible for you to supply us with the information on the process, finishing, and production of nails, in addition to the names of the manufacturers of nail machines?

—CARLOS J. ALDANESE
Aboitz & Co., Inc.
Cebu City,
Philippine Islands

Ed.—From what we understand, all you need is a source of supply for

DIE CASTING—

the fastest and most economical route from raw material to finished product



CASE HISTORIES FROM MT. VERNON FILES

Fast production with *economy*—that's die casting's supremely important contribution to the needs of today. For die casting is industry's versatile top-speed, money-saving production tool.

Take, for example, the Lewyt Corporation. Even as vacuum cleaners march steadily along its production lines, a division of the plant is being devoted to manufacture of components for military radio transmitter-receiver sets.

Shown here, is a Lewyt-made, panel-mounted dial drive assembly. The gear train housing, produced by Mount Vernon, is cast in two matching halves, *complete with bushings and all details as specified.* With a minimum of machining, a tight fit of the two portions is obtained, and the housing is ready to receive the intricate gear assembly needed for coupling the megacycle and one-tenth megacycle controls, and other parts, to each other.

However complex or simple *your* product, and however critical the dimensional accuracy it demands, it is very probable you can produce it most profitably by Mount Vernon die casting. So send us your specifications. Our wealth of specialized knowledge is at your disposal, and we'll gladly make recommendations based on your particular needs.

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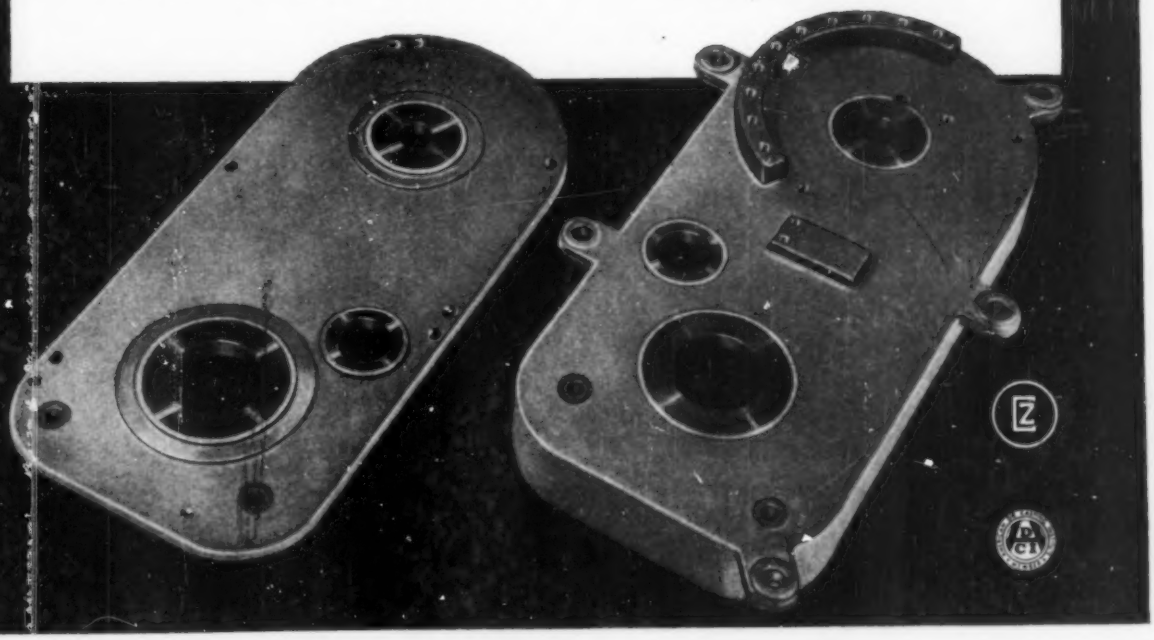

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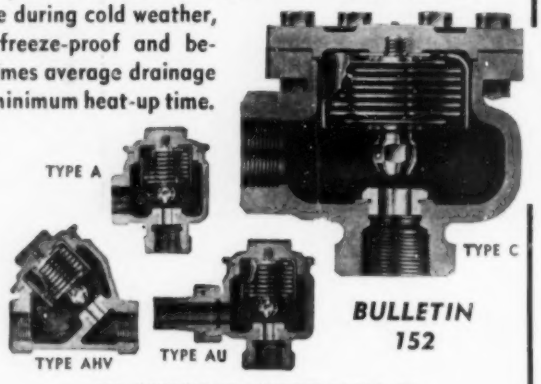
for Every Plant Use

Because they drain completely when cold, these four types of Nicholson steam traps are positively freeze-proof. Can be freely installed outdoors. Universally recommended for use in lines which need not be in continuous use during cold weather, because they are freeze-proof and because their 2 to 6 times average drainage capacity results in minimum heat-up time.

The non-air-binding feature of Nicholson traps also notably facilitates heat transfer in severe weather. Sizes ¼" to 2"; pressures to 250 lbs.



BULLETIN 152

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ON ROUGH, TOUGH JOBS

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Durakool ALL-STEEL MERCURY Switches

material and a good nail machine. Some manufacturers of these machines are: Eastern Nail Co., E. Providence, R. I.; The Ohio Electric Mfg. Co. Black Nail Div., Cleveland, Ohio; National Machinery Co., Tiffin, O.; and C. G. Garrigus Co., Haddam, Connecticut. We feel that such companies are better qualified to explain the process of manufacturing nails, and suggest you contact them.

More Power for Sudden Death

To The Editor:

The suggestion in your editorial in the October 1952 issue of PRODUCT ENGINEERING will probably never meet with much response. It's too honest and too forthright! But, as an admirer of much of the wisdom of the old guilds, and also as a Jeep Station Wagon driver I wanted to shout a loud, "Good for George" after reading it! —G. C. QUINN
Allis-Chalmer Mfg. Co.

To The Editor:

It pleased me very much to read your editorial in the October 1952 issue of PRODUCT ENGINEERING.

A firm stand on this subject is certainly commendable; one which I share with you. It does, or should appear odd that in the light of mounting mortality rates due to auto accidents the horsepower ratings continue to climb.

Perhaps if more effort were expended in safety features rather than in speed and pick-up, the automobile might better fulfill its original mission as a means of transportation instead of a means for destruction.

—ALFRED J. KOOREY
Aeronautical Engineer

Ed.—Hear, hear!!

More Data on Computers

To the Editor:

I am an engineer with the Ordnance Guided Missile Branch of Redstone Arsenal in Huntsville, Alabama.

My Section Chief requested that I write you to see if it is possible to secure more information from the manufacturer on the items mentioned in the article "Sensing Device Turns Computer into Robot" as appeared in the April 1952 issue of PRODUCT ENGINEERING. —FRANCIS F. HINCKLEY

Ed.—We suggest that you write directly to the Jacob Instrument Company, 4718 Bethesda Ave., Bethesda, 14, Md. Engineers of this company

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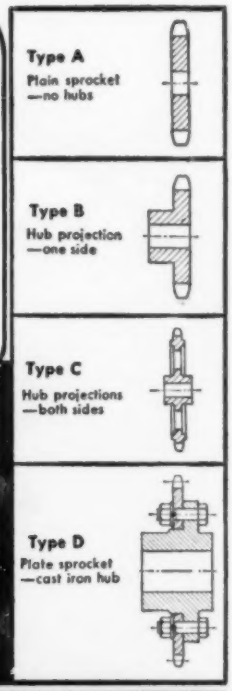

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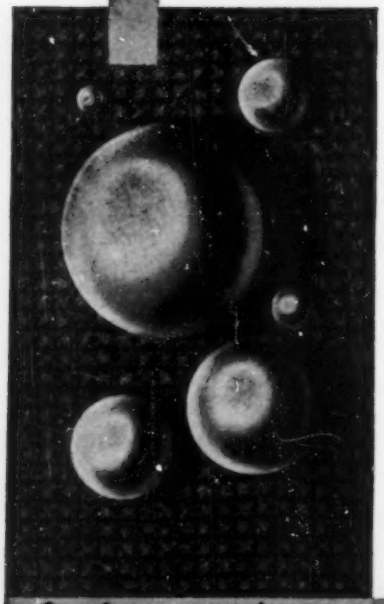

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have done considerable development work on both magnetic sensing devices and optical units for use with computers. We suggest you be as specific as possible in explaining your problem, since the use of the devices described is limited to one type of computer, the JAINCOMP, described in PRODUCT ENGINEERING, Dec. 1951, p.186.

Any Contests for New Product Design?

To the Editor:

We have heard at different times of awards being given for the design of new products and understand there is a contest of this nature held annually.

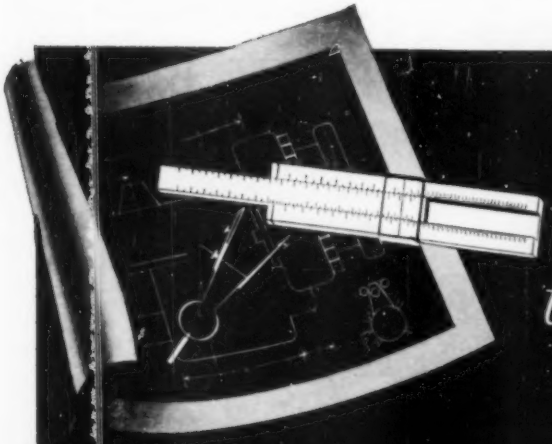
If you know of such a contest will you kindly let us know the details so we may enter one of our most recent designs? —W. A. PFAFF
Flofilm Div.
Diebold, Inc.

Ed.—Several companies sponsor design contests, some annually, others irregularly. You'll find announcements of these as they occur in the Technical News Section of Product Engineering. Some of those that are currently running include: $30,000 contest for mechanical design of machines or components made by arc welding sponsored by the James F. Lincoln Foundation of Cleveland, Ohio; Hess Brothers Awards for Versatility in Design sponsored by the Hess Store, Allentown, Penna.; Heli-Coil Award Program (see p.195).

ERRATA

September 1952, gatefold opposite page 182, *High Speed Photography in Design.* Color code at top should be reversed. Opposite black line it should read, "Optical components optional in the type of camera illustrated;" opposite red line it should read, "Optical components essential in the type of camera illustrated."

In Our Readers Say Column of the October 1952 issue of PRODUCT ENGINEERING a request was made for more information on a new process known as hydro-forming, a method of drawing simple or intricate shapes in all kinds of sheet metal. We neglected to mention the Cincinnati Milling Machine Co., Cincinnati 9, Ohio, who also use this process. Presses are now capable of handling blank diameters up to 26 inches.



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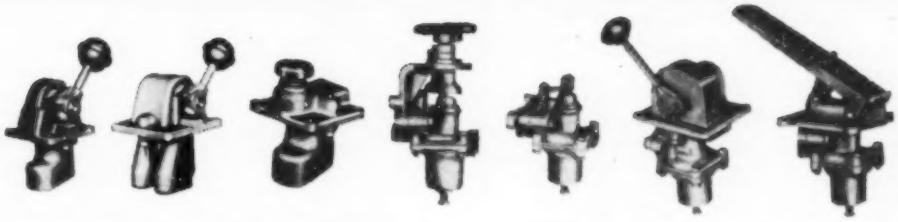

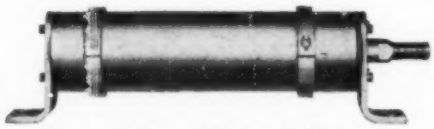

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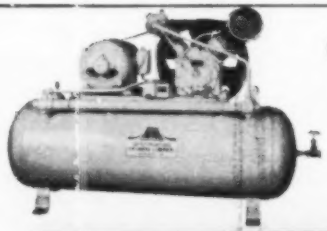
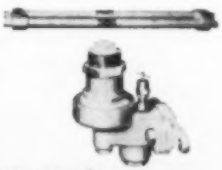


Compressors for a wide range of jobs



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Hills-McCanna Diaphragm Valves can eliminate the problems involved in valving many of the so-called "hard-to-handle" fluids. By employing a simple pinch clamp principle, Hills-McCanna valves put an end to leakage, repacking and contamination.

Hills-McCanna Valves are available handwheel or lever operated or for operation by pneumatic or hydraulic cylinders, diaphragm motors, electric motors, etc. Choice of 14 diaphragm materials, 49 body materials. Sizes from ⅜" to 14". Suitable for pressures to 150 psi., temperatures to 180° F. (higher with special materials). Screwed or flanged connections.

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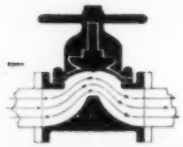
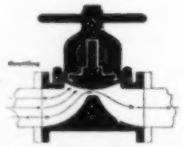
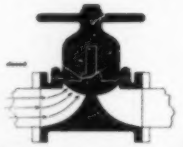


Compressor is raised, lifting diaphragm by means of a stud molded into the material.



Compressor and diaphragm partially lowered. Compressor design guides and supports diaphragm.



Compressor presses diaphragm tightly against weir, pinching off flow and making a tight seal.

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saunders patent diaphragm valves

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NEW BOOKS

Techniques of Plant Maintenance—1952

182 *pp*, 8½ x 11 *in. Published by Clapp and Poliak, Inc.*, 341 *Madison Ave., New York* 17, *N. Y.*, $6.

This book is a complete transcript of formal papers delivered at the Third Plant Maintenance Conference sponsored by the American Society of Mechanical Engineers and the Society for the Advancement of Management held in January 1952 concurrently with the Third Plant Maintenance Show in Philadelphia.

It includes also the questions put to speakers and answered by them on the platform, as well as their answers to questions that the conference time schedule did not permit them to deal with. Only the substance of the 15 concurrent round table conferences, projected as "off-the-record" to encourage free discussion, is not here.

The subjects covered are: Maintenance Costs, How to Maintain Plant Buildings, How to Maintain Electrical Equipment, Maintenance in Chemical Plants, Maintenance in Metal-Producing and Metal-Working Plants, Project Preparation and Cost Control, Preventive Maintenance, Maintenance Problems of the Small Plant, Maintenance Problems of the Medium-Sized Plant, Maintenance Problems of a Large Plant, Training Maintenance Workers and Supervisors, and Lubrication.

Physics For Modern Times

A. MARCUS. 762 *pp*, 5¼ x 8¼ *in. Published by Prentice-Hall, Inc.*, 70 *Fifth Avenue, New York* 11, *New York*. $4.90.

What is the best way to teach physics to high school students? As a technical course or as a cultural course?

The author of this new high school text feels that secondary school educators have missed the boat in trying to teach physics purely as a technical subject ignoring the cultural aspects of the science.

In Phyhics for Modern Times, the subject material is presented to permit an understanding of the concrete objects of every day physical environment. The author has removed the stress placed on the solution of specific problems in usual high school texts

and therefore was able to increase the scope of material covered.

For instance, most high school physics books cover dc electricity completely because the mathematics are comparatively simple and can be handled by the average student. But there is practically nothing on ac electricity, though the pupil meets this type of power far more often. The reason: mathematics of ac circuitry is complicated, beyond the ken of a high school education, so pupils cannot solve problems.

With this new philosophy, Marcus has written a physics text that is easy to understand and covers the fields of mechanics, electricity, heat, electronics and nucleonics. But the emphasis is placed on exploring every day phenomena, in a manner that any high school student can appreciate.

Methods of Applied Mathematics

F. B. HILDEBRAND, *Associate Professor of Mathematics, Massachusetts Institute of Technology. One of Prentice-Hall Mathematics Series,* DR. ALBERT A. BENNET, *Editor,* 6x9 *in.,* 523 *pages. Published by Prentice-Hall, Inc.,* 70 *Fifth Avenue, New York, N. Y.* $7.75.

The purpose of this volume is to place at the disposal of the engineer or physicist the basis of an intelligent working knowledge of a number of facts and techniques relevant to four fields of mathematics which are not usually treated in courses of the advanced calculus type, but which are useful in varied fields of application. The text is taken from material originally prepared in mimeographed form for use at the Massachusetts Institute of Technology.

Since most students in the fields of application have neither the time or inclination for the study of elaborate treatments of each of these topics from the classical point of view, this approach is avoided. At the same time, since the efficient use of facts or techniques depends on a good understanding of the basic principles, care has been taken to provide rigorous proofs or to state the desired results as precisely as possible and indicate why those results might have been formally anticipated.

In all cases, the procedure consists of showing how typical problems may arise, of establishing those parts of the relevant theory which are of principal practical significance, and of developing techniques for analytical and

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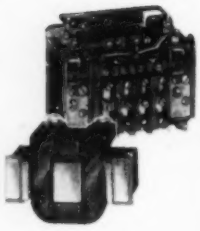

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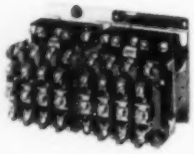

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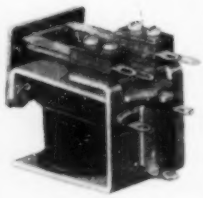

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numerical analysis and problem solving.

Although it is assumed that a course in advanced calculus has been completed, the treatments are almost completly self-contained, so that the nature of the preliminary course is not too important.

The first chapter deals principally with linear algebraic equations, quadratic and Hermitian forms, and operations with vectors and matrices with emphasis on the concept of characteristic values. A summary of corresponding results in function space is included for comparison and for convenient reference.

The second chapter covers the variational notation and derives the Euler equations. More than usual emphasis is placed on the significance of natural boundry conditions. Generalized coordinates, Hamilton's principle, and Lagrange's equation are treated and illustrated within the framework of this theory. The chapter concludes with a discussion of the formulation of minimal principles of the more general type, and with the application of direct and semidirect methods of the calculus of variations to the exact and approximate solution of practical problems.

The third chapter combines the presentation of available methods for solving the simpler types of difference equations with a description of the application of finite-difference methods to the approximate solution of problems governed by partial differential equations, and includes consideration of the troublesome problems of convergence and stability.

The concluding chapter deals with the formulation and theory of linear integral equations, and with exact and approximate methods for obtaining their solutions, emphasis being placed on the several equivalent interpretations of the relevant Grun's function.

Basic Mathematics for Engineering and Science

WALTER R. VAN VOORHIS, *Prof. of Mathematics and* ELMER E. HASKINS, *Assoc. Prof. of Mechanical Engineering, Fenn College.* 619 *pp,* 5¾ x 8½ *in. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York* 11, *N. Y.,* $7.65.

The purpose of this book is to blend the essential topics in college algebra, trigonometry, and analytic geometry into a unified subject that would prove to be interesting, vital, and directly useful in related courses and subse-

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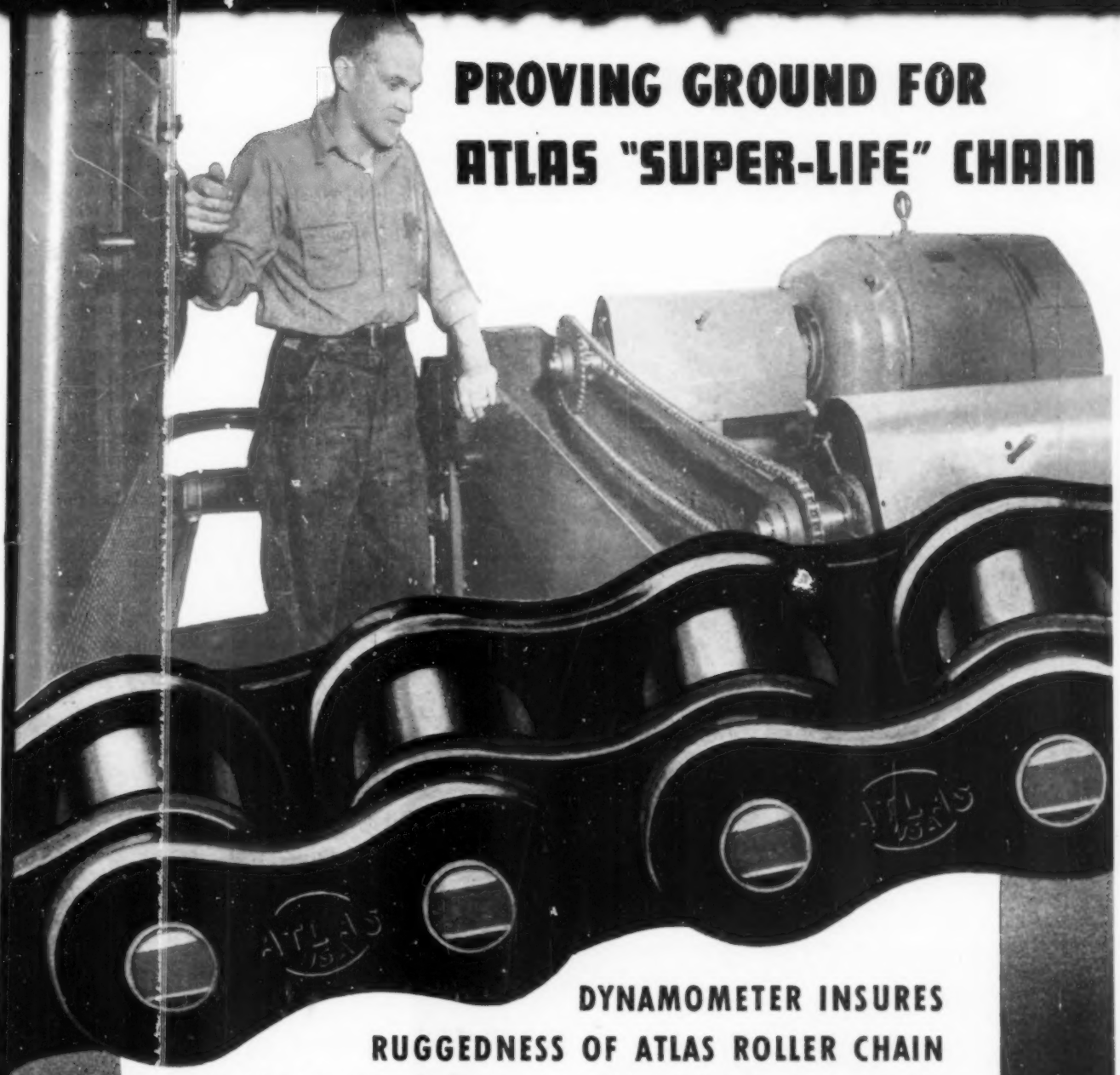

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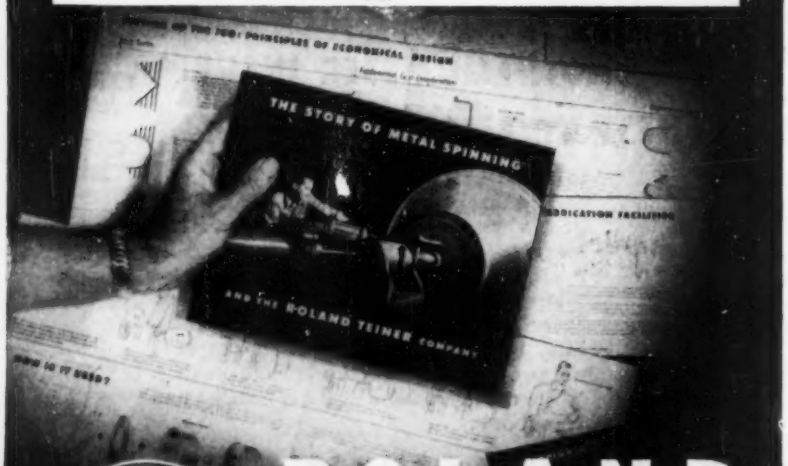

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quent fields of application. The material was selected after careful testing and revising in many classes of students majoring in engineering, physics, chemistry, mathematics and other sciences.

In the presentation, applications in science and engineering are emphasized and attempt is made to give the reader an appreciation of the inter-relationship of mathematics with other subjects. For example, the treatment of linear functions is correlated with problems encountered in tne study of forces, uniform motion, electricity, etc.

Useful techniques are introduced early and are repeated when they can be applied to clarify a procedure. The introduction to such concepts as the limit of a sequence, convergence and divergence, and space coordinates not only provides a source of interest and motivation, but also serves as a sound preparation for many phases of calculus. Likewise, the study of a few of the techniques of probability and applied statistics suggests some of the phases of the application of mathematical procedures to industrial problems of current interest.

Linear Algebra and Matrix Theory

ROBERT R. STOLL, *Prof. of Mathematics, Oberlin College.* 272 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York* 36, *N. Y.,* $6.

This text covers that part of modern algebra which underlies the theory of matrices, together with an interpretation of all results for matrics. Alternatively, it may be described as a text on the theory of matrices viewed against the background of modern algebra.

The principal topics in algebra covered include: (1) a determinant-free method of solving systems of linear equations over an arbitrary field, (2) finite dimensional vector spaces, (3) bilinear, quadratic, and Hermitian functions and forms on a vector space to its field of scalars, (4) linear transformations on a vector space, including an exhaustive study of canonical representations of linear transformations (elementary divisor theory), (5) vector space over the real and complex field, together with the important types of linear transformations on such spaces, (6) introductions to the study of fields, rings and groups.

The text is designed to present against the background of linear vector spaces, topics in algebra that are be-

coming of ever-increasing importance in a wide variety of fields—including economics, psychology, and statistics in addition to the engineering sciences, physics, and mathematics.

It provides the student of engineering physics with the necessary algebraic background for studying circuit theory, vibration theory, and dynamics of particles.

This volume also serves to introduce mathematics students to the techniques and point of view of modern algebra via concrete examples from matrix theory, while simultaneously studying matrix theory.

General College Mathematics

W. L. AYRES, CLEOTA G. FRY, H. F. S. JONAH, *Department of Mathematics, Purdue University*, 280 *pages*, 6 x 9 *in. Published by McGraw-Hill Book Company*, 330 *W. 42 St., New York* 36, *N. Y.* $3.75.

This book has been designed as a text book for a one-year course in mathematics at the Freshman level, and is intended to furnish a general education in the field of mathematics for students in the biological sciences, social sciences, and the humanities. While the book is considered a terminal course, it also furnishes a good foundation for students who wish to continue into analytical geometry.

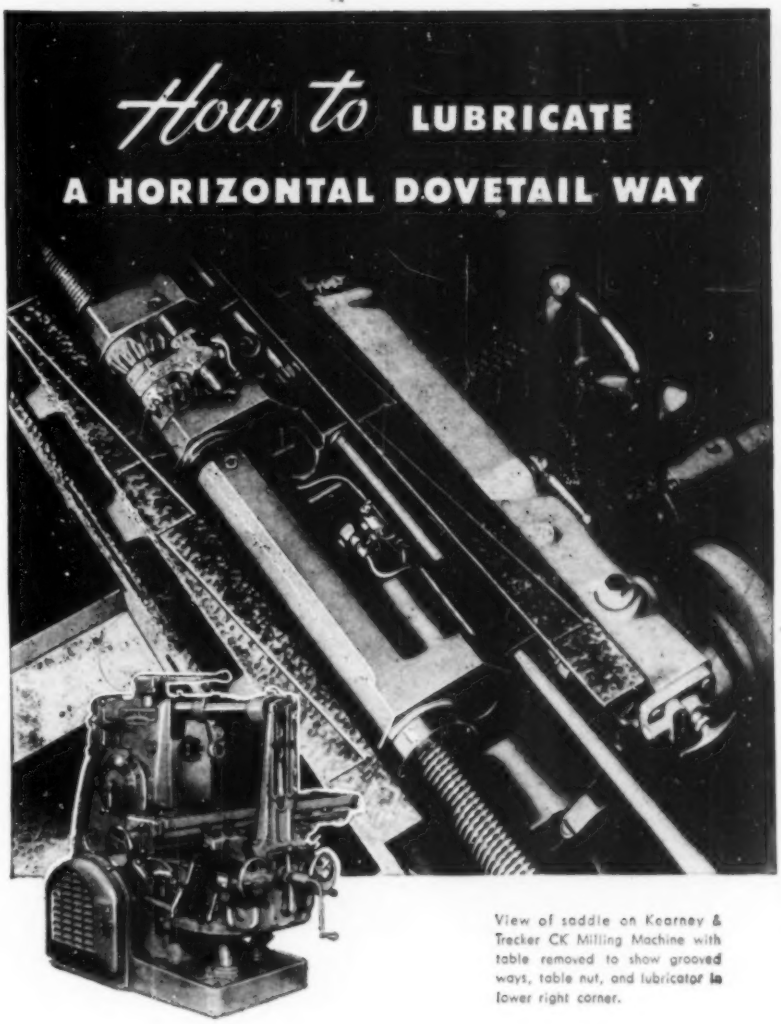
Topics covered are: algebra through quadratics, ratio, proportion and percentages, some simple trigonometry, compound interest with emphasis on installment buying, growth (population problems, decay of radioactive substances), probability and statistics, some modern mathematics, and a chapter on elements of logic.

The approach used in this book is from the point of view of a general mathematical educator, therefore, a clear statement of fundamental principles have been used instead of lengthy drill techniques and formula solutions.

Metallurgical Engineering Volume I— Engineering Principles

REINHARDT SCHUHMANN, JR., *Massachusetts Institute of Technology*, 7½ x 10, 390 *pp. Published by Addison-Wesley Press, Inc., Cambridge, Mass.* $7.50.

The first volume of a two-volume work which recognizes the need for reorganization of instruction in extractive metallurgy to meet the changing outlook of the metallurgical



View of saddle on Kearney & Trecker CK Milling Machine with table removed to show grooved ways, table nut, and lubricator in lower right corner.

. . . as KEARNEY & TRECKER does it with a **BIJUR SYSTEM**

To maintain a constant oil film between the table and saddle ways and also between the saddle and knee ways was the problem here. Both problems were solved by building a lubricator into the saddle . . . controlling the oil flow thru a system of meter-units at all four ways and both knee and table nuts . . . spreading the oil evenly over all way surfaces thru "Z" grooves in the saddle ways. This is another example of Bijur "teamwork for bearing protection." For aid in solving your lubrication problems, call in a Bijur engineer.

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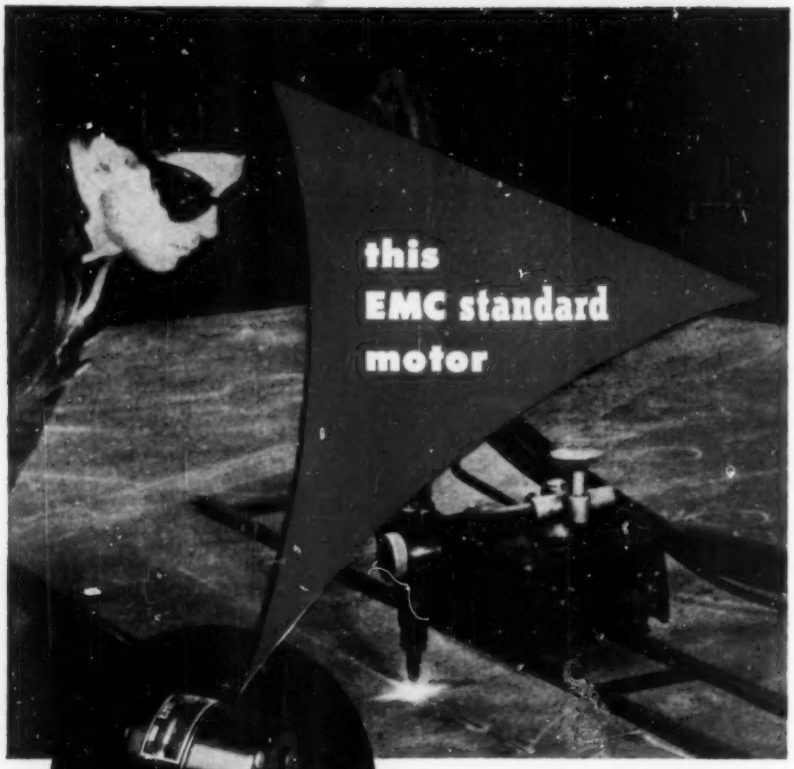

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You can tell a motor by the company it keeps!

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profession. It deals with chemical metallurgy in terms of basic scientific and engineering principles.

Three objectives in particular are sought in the book:

First, to present the subject matter of metallurgical engineering organized according to the basic principles and unit processes rather than in accordance with metals treated;

Second, to integrate the important underlying science of physical chemistry with metallurgical engineering rather than leave it entirely apart in separate courses;

Third, to place greater emphasis on analysis and quantitative solution of engineering problems, with lesser emphasis on descriptive knowledge of current practices.

This volume deals with the engineering principles common to all the unit processes. It includes extensive applications of the First Law of Thermodynamics, which are presented to show, as clearly as possible, the bridge between rigorous scientific statements of the principles and the frequently less rigorous engineering applications.

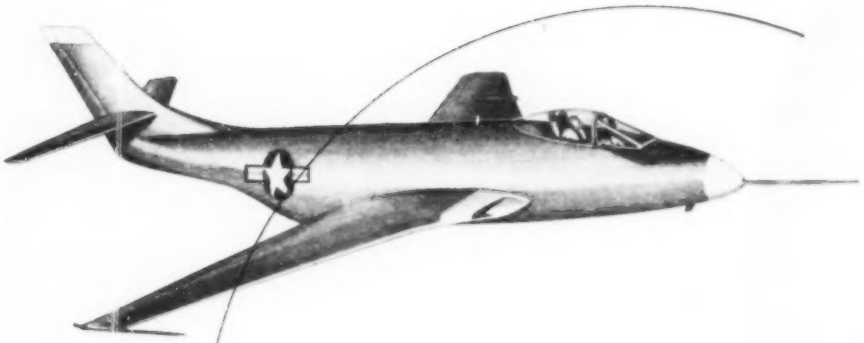
Strain Gages— Theory and Application

PROF. DR. IR. J. J. KOCH, IR. R. G. BOITEN, *TNO—Netherlands Industrial Organization for Applied Scientific Research, Section for Research of Stress and Vibration, Delft; and* IR. A. L. BIERMASZ, G. P. ROSZBACH, G. W. VAN SANTEN, *Philips Industries, Eindhoven,* 95 *pp,* 6½ x 9 *in., Elsevier Press Inc.,* 402 *Lovett Blvd., Houston* 6, *Texas,* $2.75.

For measuring strains and stresses in structures, machinery and engines, strain gages have proved to be a most valuable aid and of universal use. In recent years considerable research has been devoted to the development of these strain gages and of instruments for measuring according to this new technique. As a consequence of this development, strain gages and measuring instruments in which they are incorporated have found many important and wide fields of application.

Numerous data have been published in various scientific journals, but from such articles anyone just starting to use strain gages will not find it easy to obtain the information that is of the greatest importance to him.

This book provides a concise but comprehensive description of the technique of measuring with strain gages and everything appertaining thereto. It forms a manual compiled from many years experience in the practical



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In many other products, from steam irons to searchlights, LINEAR Silicone "O" rings have provided resilient sealing against oxidation, prolonged weathering or temperature extremes. A complete range of Silicone rubber stocks to meet AMS-3301A to AMS-3305A requirements or for other tough conditions is available. To simplify design—to lower costs—consult LINEAR for all your sealing needs.

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2. Rinsing the cleaned aluminum surfaces
3. Coating with "Alodine"
4. Rinsing with clean water
5. Rinsing with acidulated water
6. Drying

After treatments. Alodized aluminum provides an ideal bonding surface for paint, wax, adhesive, or other organic finishes. These should be applied in accordance with the manufacturer's directions. Unpainted or exposed areas will be protected by the tough, durable "Alodine" surface.

Flight of the Chance Vought Cutlass, seventh in a line of outstanding fighters and "potentially capable" of flying faster than any other service type jet aircraft in production, land or carrier-based. Substantial surface areas of the Cutlass are constructed of painted Alodized aluminum.

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"Alodine" applied by immersion or spray complies with the rigid performance requirements of both industrial and Government specifications. The following is a list of Service Specifications which "Alodine" meets at the present time.

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MIL-S-5002
AN-F-20
U. S. Navord O.S. 675
AN-C-170 (See MIL-C-5541)
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Parts can be treated by immersion, by spraying in an industrial washing machine, by flow coating, or by brushing. This means that "Alodine" can be used anywhere, on any part or product made of aluminum. This had led to widespread use of the Alodizing process: 1. by fabricators of aluminum products in all industries to assure the utmost in product protection and finish durability; 2. by manufacturers of aluminum who are supplying Alodized aluminum sheets and coils from the mills.

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use of strain gages and dealing with all those matters which must be known to ensure success in the application of this technique.

Chapter heads are: Construction and Properties of Strain Gages, Measuring Instruments, Technique of Cementing and Connecting Strain Gages, Evaluation and Interpretation of the Values measured with the aid of Strain Gages, Stresses and Theories of Failure, Application of Strain Gages in Measuring Instruments.

Electrical Measurements Manual

C. H. DUNN *and* H. J. BARKER, *Assistant Professors of Electrical Engineering, Rensselaer Polytechnic Institute. One of Prentice-Hall Electrical Engineering Series,* WILLIAM L. EVERITT, *Editor.* 6x9 *in.,* 112 *pgs. Published by Prentice-Hall, Inc.,* 70 *Fifth Avenue, New York, N. Y.* $4.35.

This book is intended for use as a text for an elementary laboratory course in electrical measurements. The first chapter presents laboratory techniques; while the remainder of the book contains a well-balanced selection of thirty-five experiments.

The experiments may be roughly divided into two categories: (1) the types and characteristics of basic electrical instruments; and (2) the use of these instruments in the measurement of electrical and magnetic quantities.

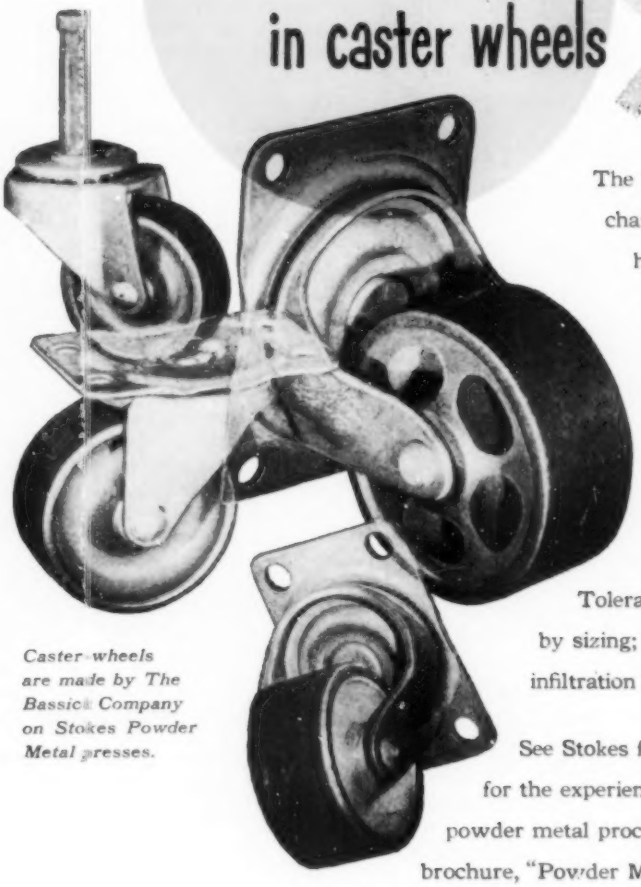
The experiments are flexible in that certain of them may be logically combined to give one experiment; while others may be conveniently broken down into two or more experiments. Alternate methods have been given in several of the experiments, where the choice of method may be affected by the availability of equipment, personal preference and accuracy. Most of the experiments are preceded by a brief discussion, and a statement of the object is given where the title is not self-explanatory. The questions at the end of each experiment point to some of the important conclusions which should be drawn by the student.

Welded Highway Bridge Design

Edited by J. G. CLARK, *University of Illinois,* 240 *pp. Published by James F. Lincoln Arc Welding Foundation, Cleveland* 17, *Ohio.* $2.

Presents the major features and new and important ideas contained in designs submitted in the Lincoln Found-

Powder metal replaces castings in caster wheels



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ation's recent through highway bridge design competition. The authors of the designs include consulting engineers, bridge engineers of state highway departments, structural engineers with governmental departments, designers of steel fabricating companies, structural engineers of research organizations and professors of structural engineering. These professionally well-known men are active designers in 17 different countries, including 20 different states in the United States.

The designs are original ideas for an all-welded two-lane through highway bridge with a span of 250 feet. The original drawings of elevations, sections and details are presented along with the author's discussion of his entry. Major features of enough of the program's designs are presented to insure that most of the new, important and useful information developed for the program is included.

The book is divided into chapters covering structural types, floor systems, new sections, connections and details, and quantities and costs. This arrangement facilitates comparison between similar features of different designs. Arches, trusses and other types of designs are represented in many variations. Floor systems include concrete, steel grid and steel plate. New sections are for plates, tees, beams, channels and angles.

Automotive Bearing Manual

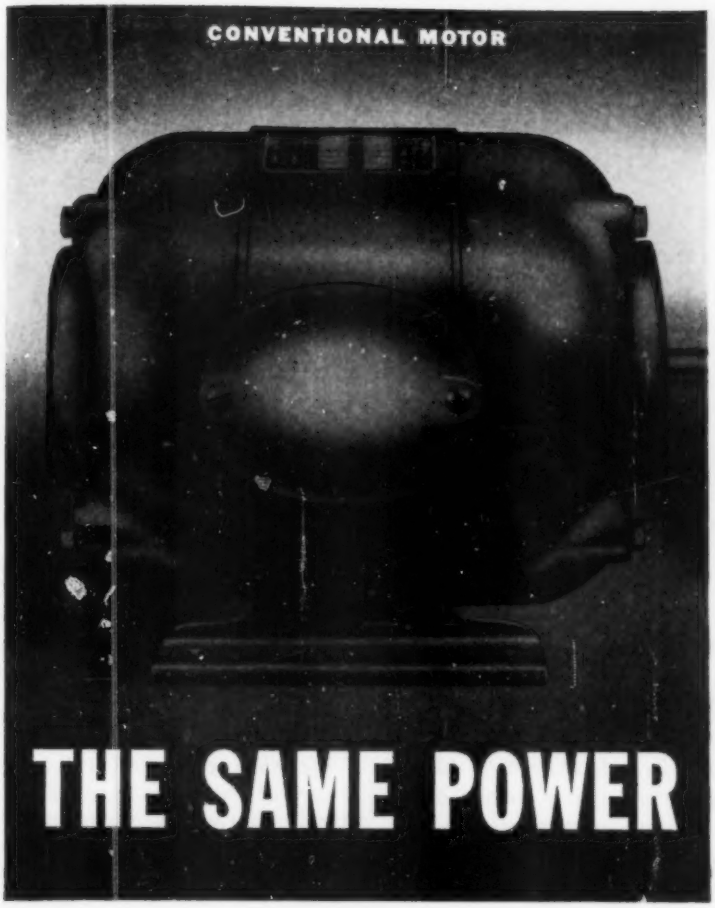
96 pp. 8 x 10 in. Johnson Bronze Company, New Castle, Pa. $1.

A well organized discussion of automotive bearings, this manual starts with basic bearing considerations, and required bearing properties. Describes and illustrates all types of bearings such as: direct babbitted bearings; non-precision bearing liners; precision insert bearings; floating type bearings; camshaft bearings; sleeve type bushings; and thrust washers.

All types of lubrication systems are explained with colored illustrations of each. Auxiliary systems and oiless systems are also discussed.

The largest section of the book is devoted to automotive bearing care. This section is sub-divided into the following groups: recognition of engine bearing difficulties; meaning and importance of precision; diagnosis of bearing difficulties; analysis of bearing failures; and correction of bearing difficulties.

Subjects like replacement without moving shaft, rod and main bolt torques, and head bolt torques are also briefly discussed.



* Depending on horsepower, reduction in length ranges from 41.7 to 50.5%!

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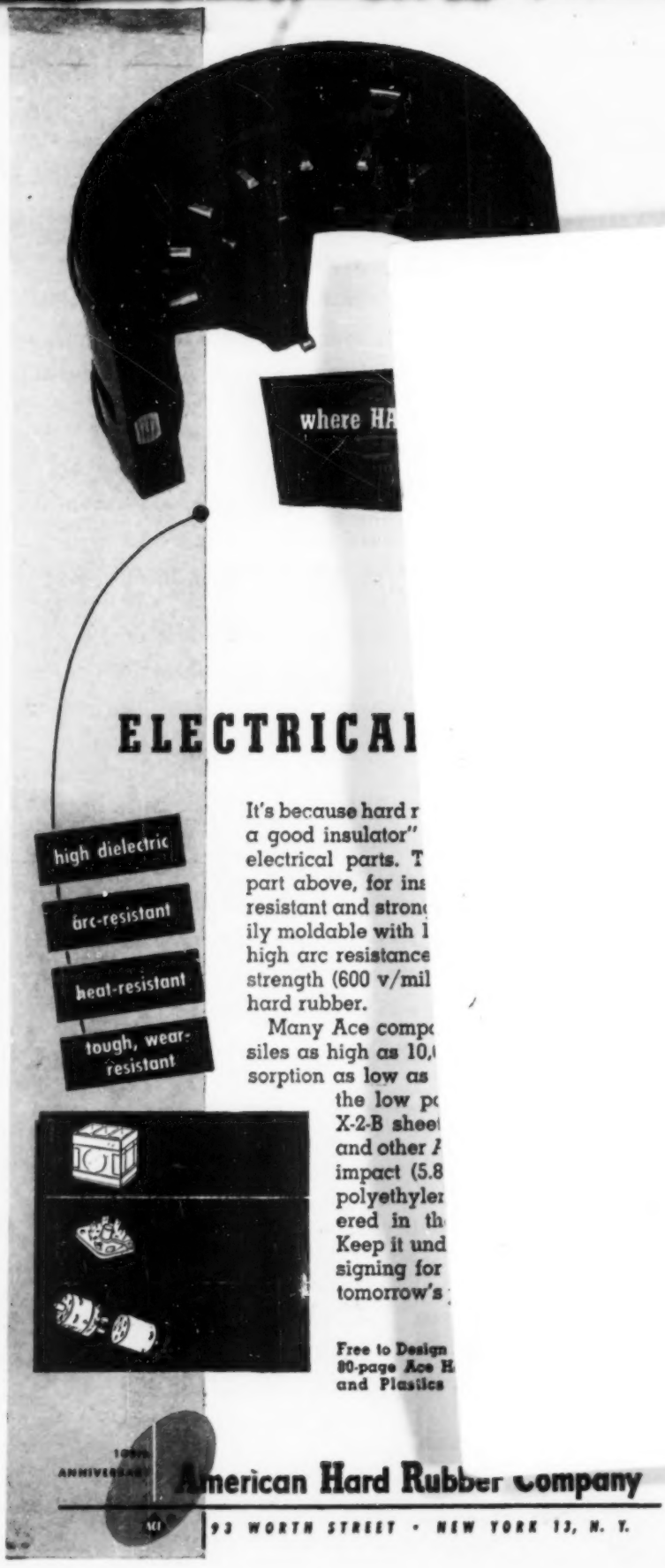

ation's recent through highway bridge design competition. The authors of the designs include consulting engineers, bridge engineers of state highway departments, structural engineers with governmental departments, designers of steel fabricating

PAC
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difficulties.

Subjects like replacement without moving shaft, rod and main bolt torques, and head bolt torques are also briefly discussed.

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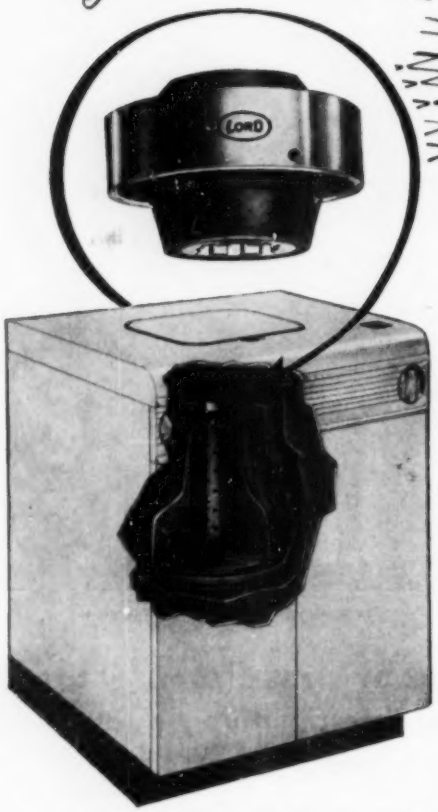

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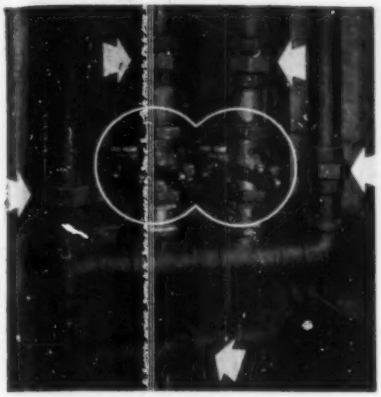

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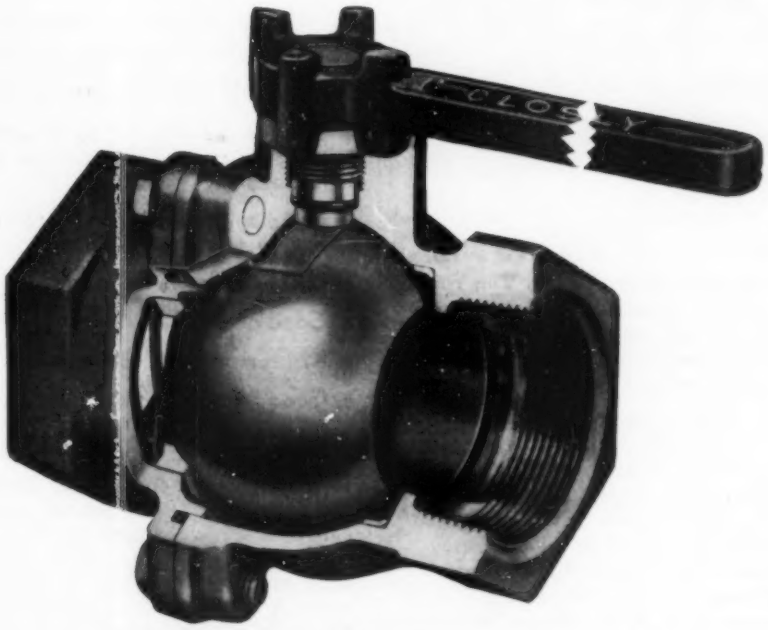

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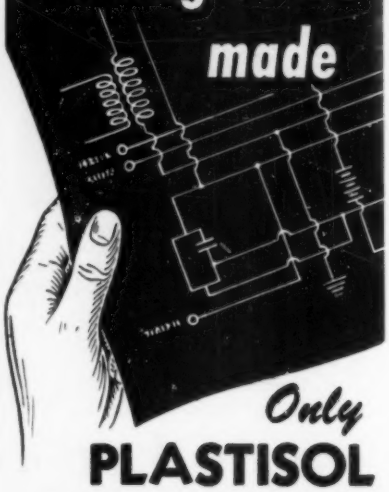

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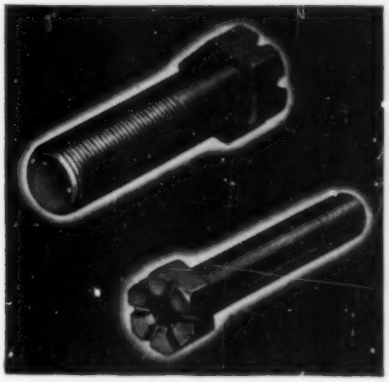
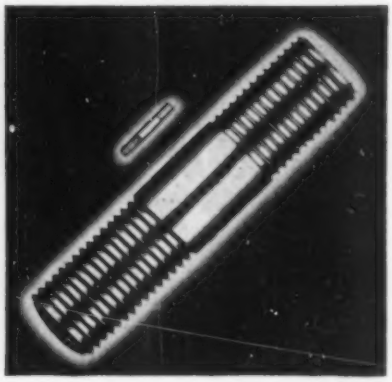
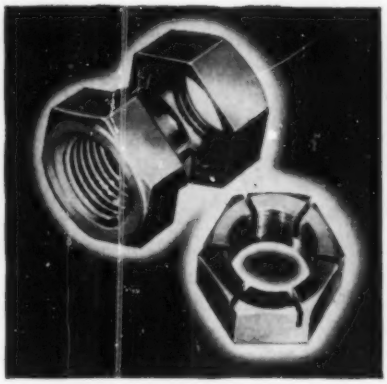


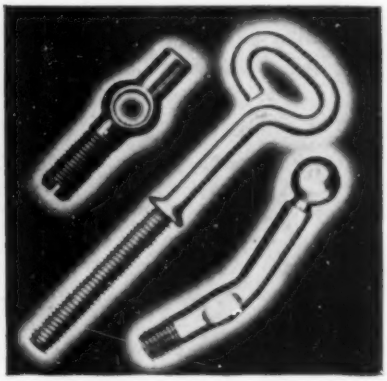
Vibration Problem? . . . The "National" Place Bolt's spring-action head, tightened against a rigid seat, locks the bolt against loosening caused by vibration, insures against impact or shock failure. Now obtainable in carbon as well as alloy steels, providing substantial cost savings.



Positive Locking-Sealing? . . . LOK-THRED bolts, studs and screws actually *become tighter in service*, under vibration. Eliminate need for selective fits and blind tapping —yet provide effective and positive sealing. Available in any size stud, bolt or screw.



Stress, Shear, Shock? . . . "National" Lock Nuts, in a variety of types, are designed to fit every fastening need...for rugged, heavy equipment where severe stress, shock or shear must be overcome . . . for fastening lightweight materials at minimum cost.



Special Fastener Needs? . . . Our engineers can help you find a solution for practically any special fastening problem . . . requiring an unusual type of bolt, nut, screw, pin or headed or threaded part. And we can produce it for you economically.

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rod, strip or tubing means economical design!

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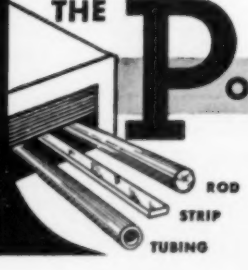

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of Pennsylvania
Reading, Pa.

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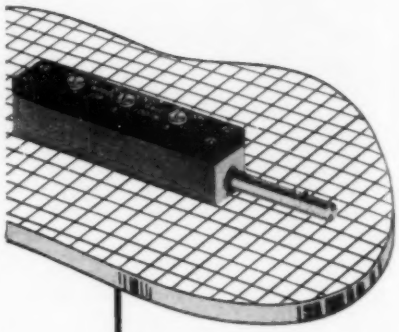

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BOURNS precision wire-wound potentiometers accurately translate mechanical position into an electrical signal. Resolution of .001 inch attainable in all standard ranges from 1 to 6 inches. Technical publication describing standard models and special applications available upon request.

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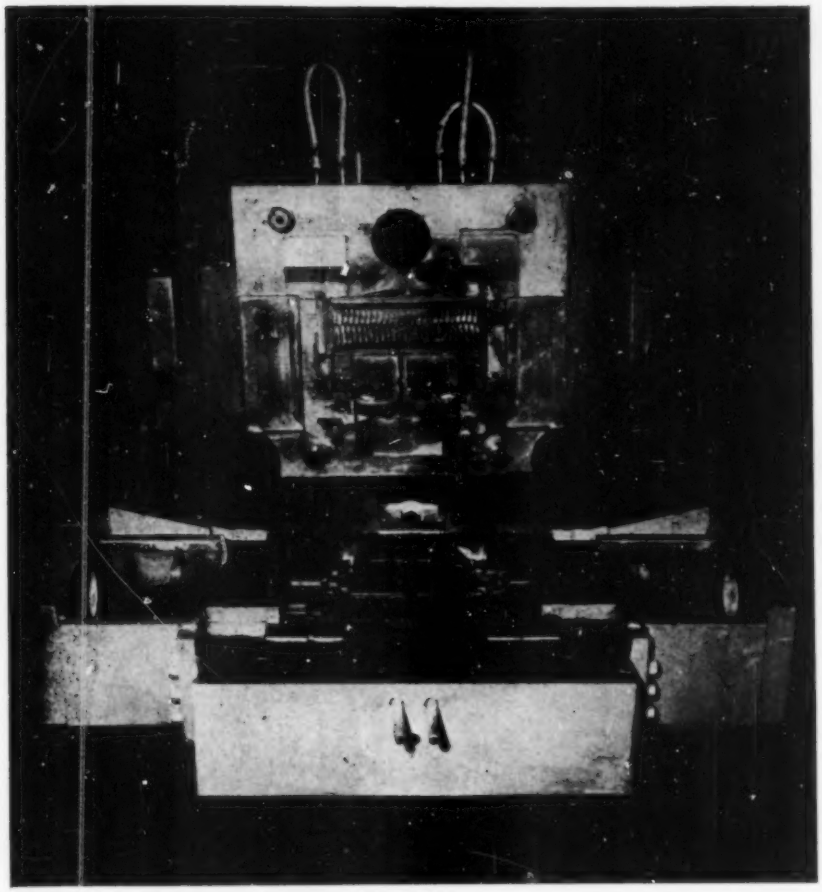

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Accuracy calls for POTOMAC M Hot Work Die Steel

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is the title of a new, six-page folder that tells about the chromium, molybdenum, vanadium Hot Die Steel known as POTOMAC M—and also covers other grades for other hot-work operations. Secure your copy —*write today!*

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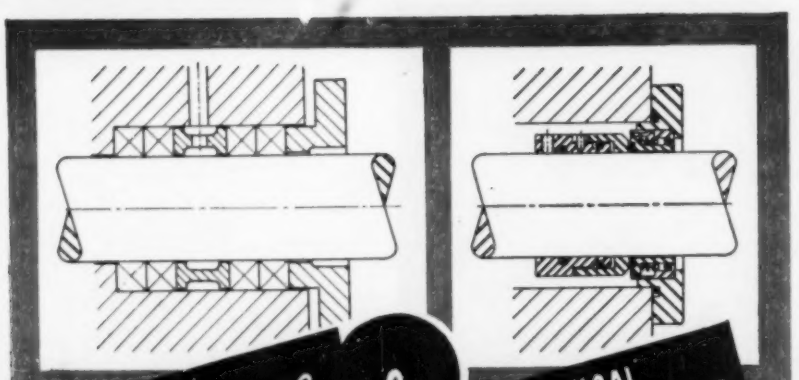

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. . . the compact rotary seal with the patented balanced-pressure design. Let us put our years of shaft sealing experience to work on your problem — whether it's sealing a pump, hydraulic motor, gas turbine, main shaft, gear box, or any rotating shaft. Send blueprints and job description to Sealol Corporation, 45 Willard Ave., Providence 5, R. I.

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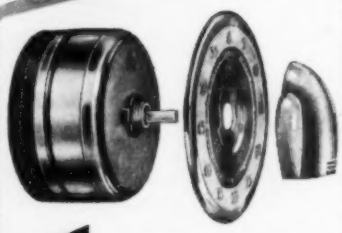
The Balanced Pressure Seal

You can depend on the rugged MARK-TIME "5400" Bell Time Switch



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UL approved for 20 ampere, 125 volt, 1 HP or 10 ampere, 250 volt operation, AC only. Timings available from 60 seconds to 5 hours. Normally supplied with center stud mounting. Other mountings available on request.

This Mark-Time switch is built to uphold the reputation of your product. Install it in your appliances, devices or machines, and give your customers a *double-purpose* time switch. "5400" turns OFF the circuit at the end of a pre-set time period . . . and gives a clear warning bell signal. Your customers will like that *double* service!

"5400" has a wide range of applications . . . is available with a wide variety of modern dials and knobs . . . can be supplied as an "ON" type of unit on special order.

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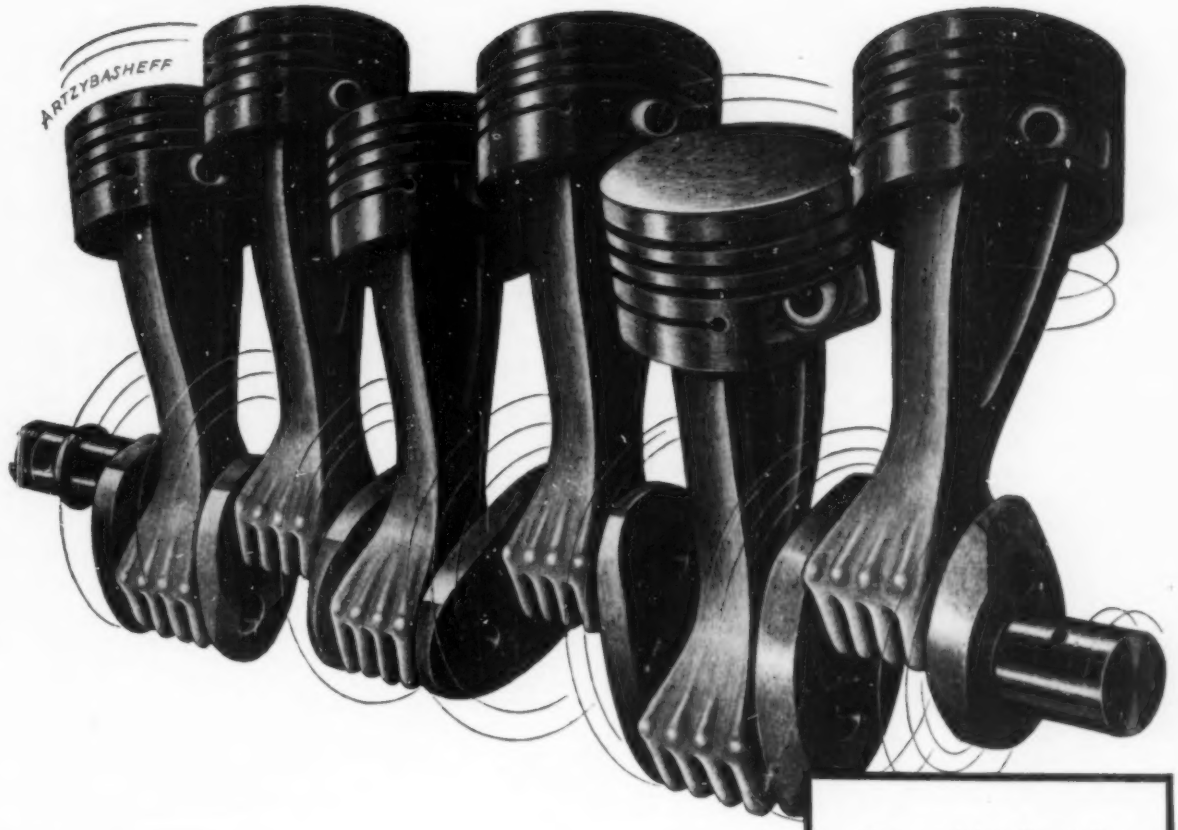

Six strong arms and "true"

Six powerful arms of steel grip and turn the crankshaft—send power from pulsing pistons surging through the mighty Ford truck. These connecting rods are machined to tolerances of 3/10,000 of an inch—diamond-bored for precision—dynamically balanced to 1/10th of an ounce for peak performance. That's precision production—and for such exacting work in great volume, Ford Motor Company depends on Lycoming.

Lycoming stands ready to assist you—whether you have "just an idea" that needs developing, a problem in the blueprint stage, or a finished metal product that needs speedy fabrication. Long famous in the metal-working field, Lycoming continues to meet the most exacting and diverse requirements, both industrial and military. *Whatever* your problem—look to Lycoming!

Lycoming's 2½ million feet of floor space, its more than 6,000 machine tools, and its wealth of creative engineering ability stand ready to serve your needs.

For precision "arms" —connecting rods that perfectly pass power along to a truck's wheels— Ford Motor Company depends on Lycoming precision production.

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Relay reliability is the enviable reputation of Automatic Relays for more than a quarter of a century! This *extra value* is added protection . . . *insurance* for continued preference for your product when you specify AEMCO Relays.

Automatic Relays are engineered to far exceed specifications . . . constructed with the care and precision usually associated with the manufacturing of jewelry . . . carefully tested by professional 'fault-finders'!

Whatever your requirements as to size, purpose, capacity, mounting, open or can type with plug-in base . . . there's an Automatic Relay to meet—*and exceed*—your specifications.

Hermetically sealed, for stud mounting, solder connection.
1-7/8x1-7/16x2-3/8 D

Heavy duty midget power relay 30 Amp. capacity. Widely used as street lighting relay and motor starting applications.
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TIME SWITCHES

Synchronous, self-starting Automatic Time Switches are encased in an attractive, tamper-proof case with a window that affords visibility of trip levers and contact position. Standard models SPST and SPDT in 10 and 20 amperes with and without skip-a-day feature. Thirty and forty-five ampere models available in single and double-pole single throw;—or twin type consisting of two sections of either single or double pole contacts for additional capacity or independent circuits. All models have easily set, new type trip levers that permit ON and OFF settings as close as 15 minute intervals.

If it's dependability you want, you'll be ahead to switch to Automatic Time Switches. Get all the facts. You can expect, *and get,* more of the features you want and need when you get Automatic!

Popular 20 Amp. single pole. Varied applications make this model a favorite.

AEMCO

WRITE TODAY for complete information specifying types of units in which you are interested.

Automatic Electric MFG. CO.

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TRADE MARK REG. U. S. PAT. OFF.

OIL-FREE

SELF-LUBRICATING

BUSHINGS

"WORK WHERE OTHERS WON'T"

Widely Used Where Ordinary Oil Lubrication Is Impractical or Impossible.

EXCELLENT DURABILITY • CONSTANT CO-EFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE — EVEN WHERE OIL SOLIDIFIES OR CARBONIZES **• OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE AND OTHER LIQUIDS • EXCELLENT FOR CURRENT-CARRYING BEARINGS**

GRAPHALLOY materials are also in wide use for oil-free, self-lubricating piston rings, seal rings, thrust washers, friction discs, pump vanes etc.

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For applications requiring low electrical noise, low and constant contact drop, high current density and minimum wear. Used for SELSYNS, DYNAMOTORS, SYNCHROS, ROTATING STRAIN GAGE pick-ups and many other applications. Brush Holders and Coin Silver Slip Rings also available.

Write for data sheets. Outline your problem and let us help solve it.

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solve that power problem

fast* with a

FLUID MOTOR by GEROTOR

- Has low rotational inertia, permitting easy control of shaft speed and direction.
- Can be stalled under load for any length of time without damage.
- Can be operated safely in explosive and corrosive atmospheres.
- Can be installed in small, confined spaces.
- Embodies the exclusive Gerotor principle, resulting in longer life, less slippage, higher efficiency at lower operating cost.

*prompt delivery NOW

Gerotor fluid motors are available in two models, six sizes, rated up to 8.7 h.p. Maximum operating pressure is 1200 p.s.i. continuous, 1500 p.s.i. intermittent. Plain, base or flange mounting, for direct coupling, belt, chain or gear drive.

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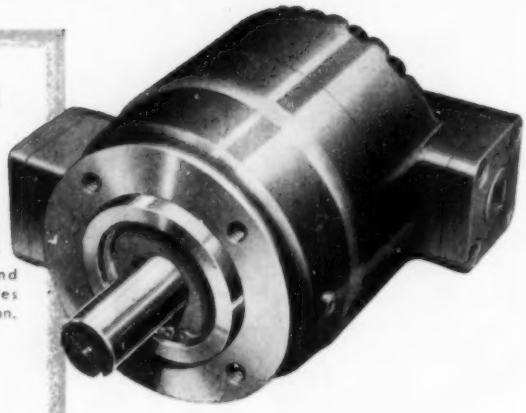
Gerotor May Corporation · Box 86 · Baltimore 3, Maryland

"The Finest Money Can Buy!"

in smoother, longer-lasting performance



Because of:

Radially Balanced Rotors

Dual, opposed inlet and exhaust porting provides radially balanced operation.

Hydraulically Balanced Vanes

Less load on cam ring . . . low loading characteristics at all operating pressures.

Simplified Design

Consisting of only three ruggedly built, close-coupled components. Pump/Motors assure extra stamina.

Highly Compact Construction

Delivering 7.5 gpm at 2000 psi, this typical Pump/Motor is only 4⅛" in width and height; only 8" long including the shaft.

Bi-directional Rotation

All Pump/Motors are quickly and easily convertible to counter-clockwise rotation, and operate with equal efficiency in either direction.

DENISON PUMP/MOTORS—*ready for either pump or motor use without alterations of any kind*—are designed and built to stand up longer, at full efficiency, under a wider range of applications calling for hard, continuous duty at 2000 psi.

Some of the features that give Pump/Motors this extra value are shown at left. In addition, their 3-unit construction makes it easy to alter the relation of inlet and exhaust porting for easiest installation. For better valving action, the heavy-duty Pump/Motor vanes feature dual, precision-machined sealing edges held in constant contact with the cam ring.

FOUR SIZES, each with a choice of interchangeable cam rings, offer pumping capacities from 2.7 to 70 gpm . . . or motor torque capacities from 13 to 257 pound-inches per 100 psi. *For smoother, longer-lasting, low-maintenance operation, specify Denison Pump/Motors.* Write for full details.

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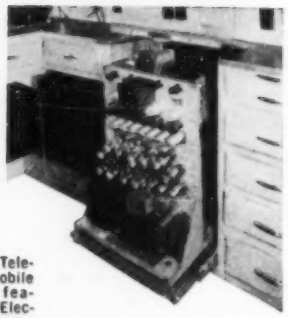
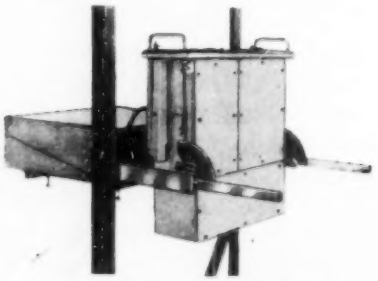
DENISON Hydr-Oil-ics

PUMP/MOTOR

GRANT ELECTRONIC SLIDES Simplify SERVICING



The Dumont Telecruiser, a mobile TV station, features Grant Electronic Slides as a component part. Picture shows distribution amplifier unit which is mounted on Grant Slides. This Unit slides out for simplified servicing.



Leading manufacturers of Electronic equipment as well as many government agencies have specified and successfully used GRANT SLIDES for many years.

Outstanding Features:

- Continuous ball bearing action
- Accurately fitted— no chassis rattle
- Pivoting and locking devices
- For loads from 25 to 2000 lbs.
- Time and manpower savings

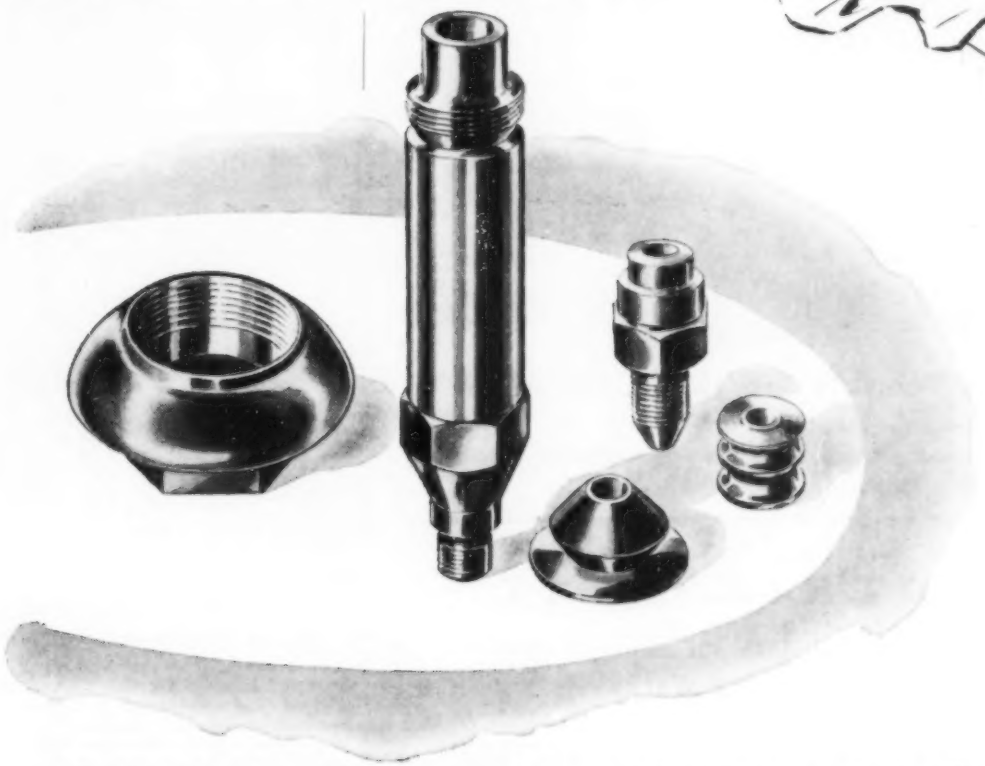
GRANT

Write Electronic Design Division for Catalogue

GRANT PULLEY & H'DW'E. CO.
31-93 WHITESTONE PARKWAY
Flushing, L. I., N. Y.
Representatives in all Major Cities

Look at that smooth finish . . .

it's CHASE® Free-Cutting Brass



Parts machined from Chase free-cutting brass, copper and bronze have a smooth, clean finish, free from rough edges. That means they're considerably less expensive to lacquer, enamel or plate. And because of their high strength and hardness, they will stand up under extensive handling and reuse. You'll get better quality production at lower unit costs when you use Chase free-cutting brass, copper and bronze. Fill in and send coupon below for free 56-page Chase book.

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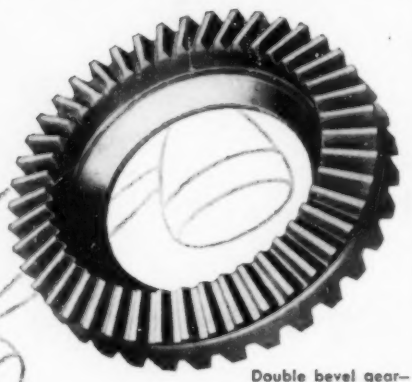

Double bevel gear—used in post hole digger

BRamble 7700 is our telephone number in Cincinnati. If you have a gear problem, call us—we would enjoy discussing it with you. We have been helping industry since 1907, and we can undoubtedly help you, too.

We are proud of our craftsmen, proud of our gears, proud of our reputation for quality. And we are proud of the fact that our customers can deal with us with complete confidence—an established, reputable firm with whom you, too, will enjoy working.

Spur	Internal
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For full information, write, wire, or call BRamble 7700.

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Offers These Facilities for Jobbing and Sub-Contracting Work:

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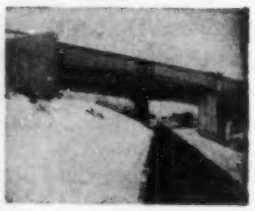


Our foundries, machine and welding shops, long experienced in meeting rigid requirements of the U. S. Navy, are well qualified to turn out a wide variety of work to exact specifications. The foundries are equipped to handle bronze castings up to 5 tons, aluminum castings of light and heavy classifications, and gray iron castings up to 10 tons. Machine shop operates lathes to 60" turnings, boring mills to 100" diameter and planers to 120" width. Crane capacities to 50 tons.

Write or telephone for full information

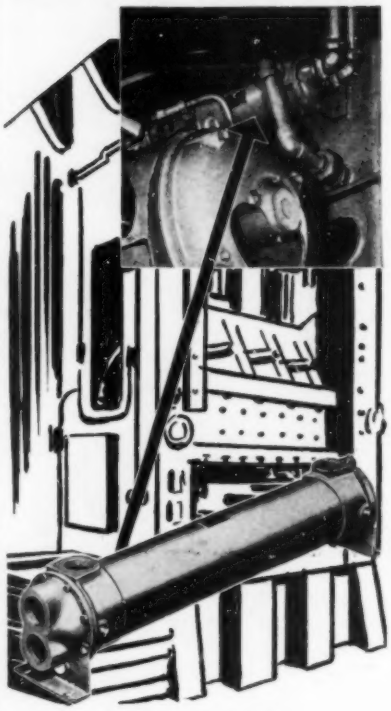
ELECTRIC BOAT

Division of General Dynamics Corporation

Groton, Connecticut

CONTROL

HYDRAULIC FLUID TEMPERATURES!



THERE ARE 132 STOCK YOUNG HEAT EXCHANGERS TO ASSURE OPTIMUM COOLING

Young standardized shell and tube heat exchangers are quality-built to control fluid temperatures and protect costly hydraulic equipment. For example, tubes are braised to tube sheets which, in turn, are braised to the shell to eliminate leakage between hydraulic fluid and coolant. Tube and baffle spacing are engineered to provide maximum heat transfer with minimum pressure drop. Immediate shipments can be made from stock. Catalog sent upon request.

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Heat Transfer Products for Automotive and Industrial Applications. Heating, Cooling, and Air Conditioning Products for Home and Industry.

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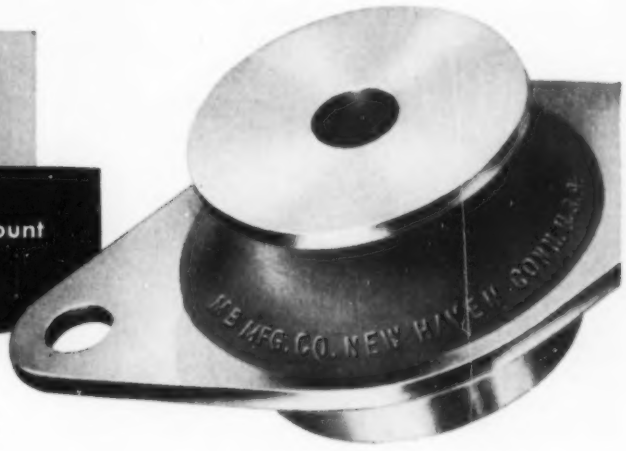
Factories at Racine, Wisconsin and Mattoon, Illinois

Vibration Engineering that solves your problems

PROBLEM: To provide superior vibration control while simplifying suspension design

SOLUTION: The Isomode* Type 5 Mount that isolates all modes of motion



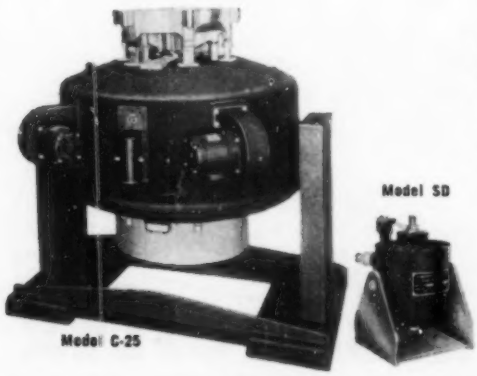
HOW to get optimum isolation into a product design? The answer is not always easy. But it was made much easier to find when Isomode Mounts were developed. They offer what's needed for outstanding results—namely, control of horizontal and rocking motions as well as vertical vibrations.

And here's why. Isomode Mounts have equal spring rates in all directions. They therefore absorb vibrations from all directions equally well. As a result, they can be mounted at any angle, permitting location of ideal suspension points and simplifying design.

In addition, Isomode Mounts have high load capacity in compact size, saving both space and weight. Large rubber volume for their size lends softness for good isolation, yet the mounts are stable, self snubbing and long lasting.

These mounts are an example of the kind of vibration engineering put to work for you at MB. Many companies have found it good practice to make MB their headquarters for vibration information. You will too—on vibration *isolation, control, testing, detection* or *measurement*. For more details on Isomode Mounts, be sure to write for Bulletin 410-6.

*Trade Mark Reg. U.S. Pat. Off.



A vibration exciter to meet your needs

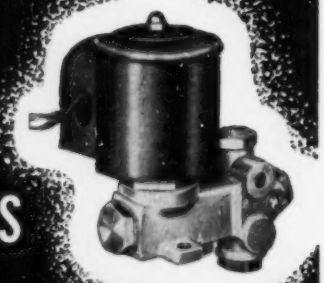
Whether your shake testing requirements are of large order or small, there's an MB Shaker for the job. Model SD, for example, has rated force output of 10 pounds; while the C-25 provides 2500 pounds. Model also available for 10,000 pounds. So if you have to vibration test to MIL-E-5272, be sure to check up with MB. Bulletin No. I-VE-6, gives technical data on MB Shakers. Write for it.

THE MB MANUFACTURING COMPANY, INC.
1060 STATE STREET, NEW HAVEN 11, CONN.

PRODUCTS AND EQUIPMENT TO CONTROL VIBRATION • TO MEASURE IT • TO REPRODUCE IT

ASCO Solenoid VALVES

Effective Automatic Control for Cylinders and Power Heads



It's versatile, this ASCO 3-way Solenoid Valve, for it can be found controlling air and hydraulic cylinders on hundreds of different machines, including:

air, gas and refrigerating compressors (for unloading)
tire moulding machines
plastic moulding presses
furnace and oven doors
conveyors of many types
metal working presses

Being "packless," maintenance is negligible. The stainless steel seats and discs (up to ⅜" size) are beveled, tight-seating and renewable. Pipe sizes range from ⅛" to ½"; port sizes from ⅛" to ⅜". It's suitable for pressures up to 500 pounds and temperatures up to 212° F. Other ASCO 3-way Valves up to 4" pipe size available.

This ASCO Solenoid Valve (Bulletin 8300) and its many companions in the broad ASCO Line are backed by more than 60 years of experience in the design and manufacture of automatic control units. This is your assurance of (1) getting the correct solenoid valve for your control problem and (2) getting a reliable valve.

When in need of Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, and Specialized Electromagnetic Controls, come to us.

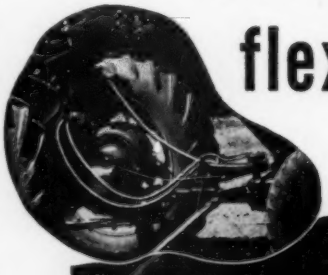
Automatic Switch Co.

If it has to be really

oilproof

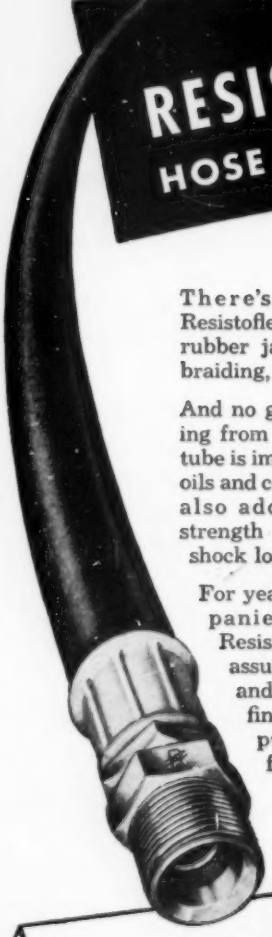
and have fatigueless

flexibility...



USE

RESISTOFLEX HOSE ASSEMBLIES



There's nothing to fatigue in Resistoflex hose – not the synthetic rubber jacket, the high grade yarn braiding, nor the compar tube.

And no gumming, eroding or swelling from oil either. For the compar tube is impervious to water-insoluble oils and compounds. The compar tube also adds more than necessary strength for medium pressures and shock loads in hydraulic systems.

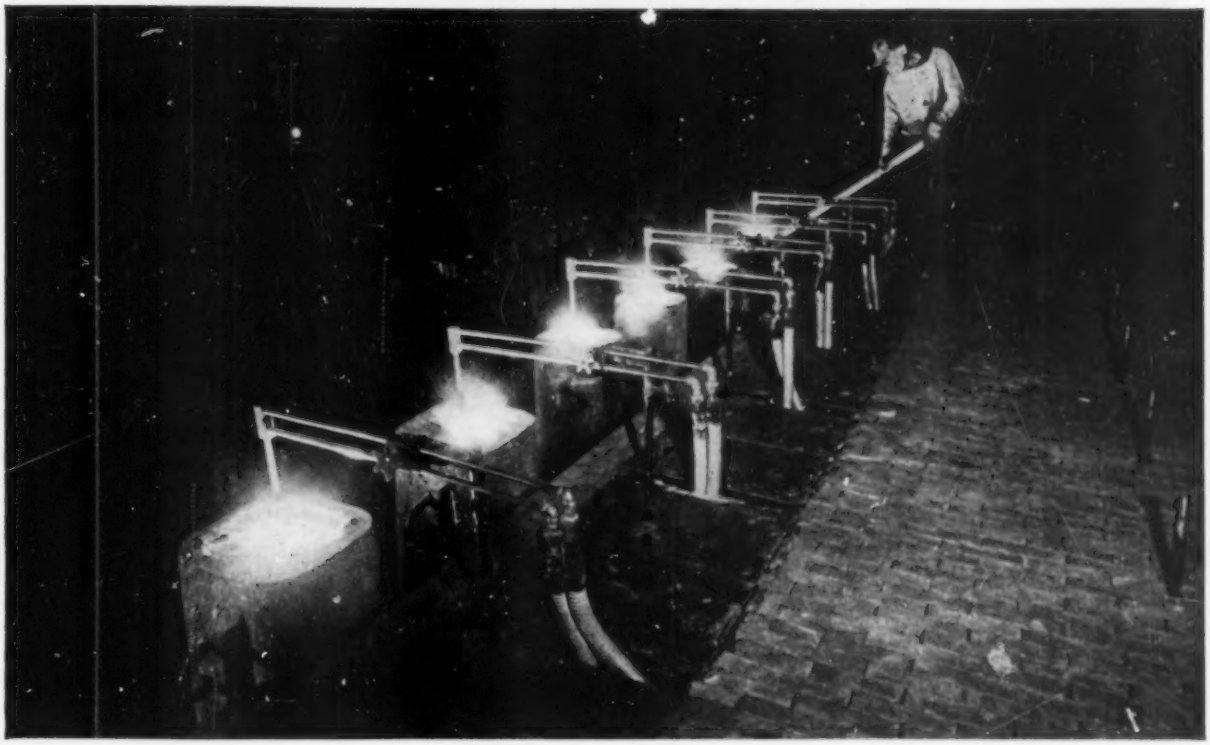
For years, many well known companies have standardized on Resistoflex Hose Assemblies to assure minimum line troubles and replacements. You, too, will find that Resistoflex quality pays off in the long run. Write for specification sheets.

For out of the ordinary engineering with synthetics

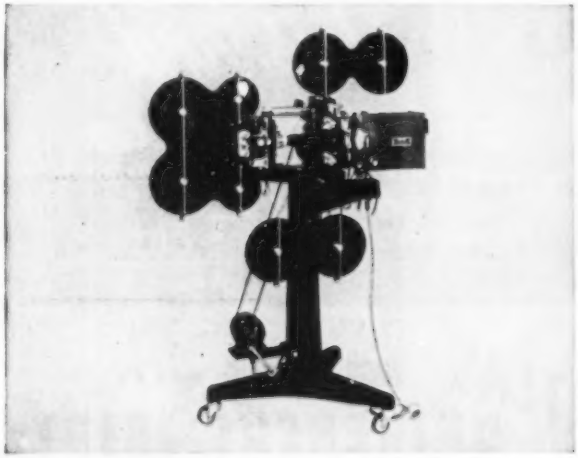
RESISTOFLEX

RESISTOFLEX
CORPORATION
Belleville 9, New Jersey

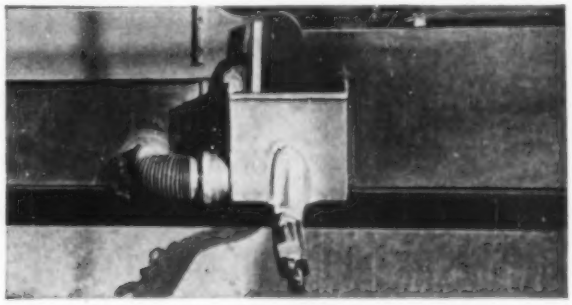
NEWS ABOUT FLEXIBLE METAL CONNECTORS
Here they offer HEAT RESISTANCE, PROTECTION, and ECONOMY



HEAT RESISTANCE The "electric hot topping" process generates a lot of heat. Braeburn Alloy Steel Corp. uses American Flexible Galvanized *Steel* Tubing to protect wiring from both this intense heat and impact. American Flexible Connectors can also be made from other metals. Use American Flexible Metal Connectors if your product must move, bend, vibrate, or resist heat, cold or pressure.



PROTECTION American Flexible Shielding Conduit was used on this motion picture film reduction printer. The manufacturer, Oscar F. Carlson Co., desired to protect wiring from crushing and impact. American Flexible Metal Connectors are often the easy solution to a tough design problem. They absorb vibration, protect flexible shafts, connect moving lines, and can be assembled in restricted spaces.



ECONOMY This American Flexible 2" ID Seamless Bronze Tubing is used between flue pan and syruping-off box on a maple syrup evaporator. The George H. Soule Co. chooses this connection because it permits more rapid flow of sap, and absorbs expansion and contraction. To carry air, oil, gases, grinder dust, and many other fluids and semi-solids—American Flexible Metal Connectors should be *your* first choice, too!

Write for Booklet SS-50: shows how the tubing is designed, used and installed – gives specifications on tubing and fittings. The American Brass Company, American Metal Hose Branch, Waterbury 20, Connecticut. In Canada: The Canadian Fairbanks-Morse Co., Ltd.

52361

ANACONDA

wherever connectors must move... *American* flexible metal hose and tubing

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New molding compounds composed of Fibre Glass, Nylon, Rubber Phenolics are making electrical components more durable and efficient, with application advantages in performance and economy. Triple "M" experts can help you in building a better product. Send your blueprint or description and functions of your unit, specifying electrical and mechanical properties required. Triple "M" will be happy to work with you in the design and production stages, without obligation.

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IMPROVE
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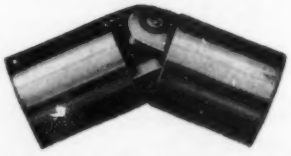
REDUCE
YOUR COSTS...



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PILOT LIGHTS
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MOUNT IN 15/32" HOLE
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Easy lamp replacement with any midget flanged base lamp types

Complete blackout or semi-blackout dimmer types

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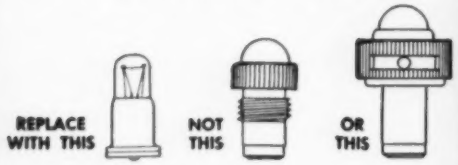
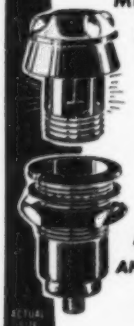
THESE ASSEMBLIES LOGICALLY REPLACE LAMPS NO. 319, 320, and 321



PLASTIC PLATE (EDGE) LIGHT ASSEMBLIES

AIR FORCE and BUREAU of AERONAUTICS
MIL-L-7806 DRAWING MS-25010



DIALCO *No. TT-51* (Red filter-black top)
or, *No. TT-51A*, complete with No. 327 Lamp

ALSO MADE
with other filter colors and with *light-emitting top* (for indication)

ALL OF THE ASSEMBLIES ILLUSTRATED ACCOMMODATE LAMPS NOS. 327, 328, 330, and 331.

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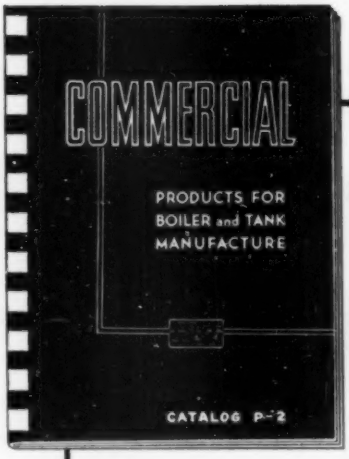

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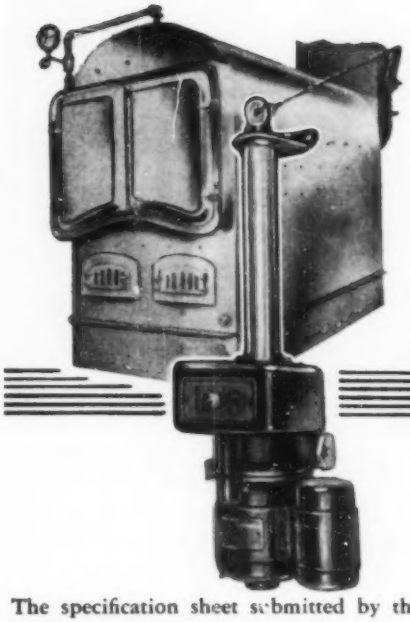
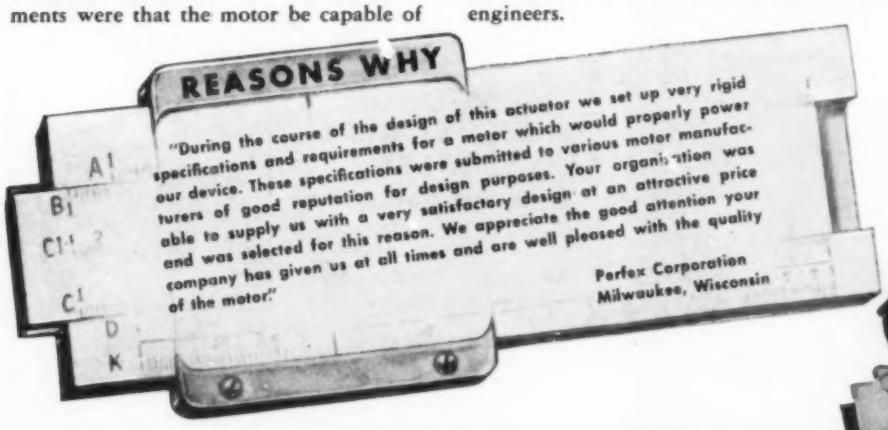


PERFEX DRAFT CONTROL ACTUATOR USES A BODINE MOTOR

The specification sheet submitted by the Perfex Corp. when shopping for a motor for their Damper Actuator listed 23 operating conditions and specific requirements that had to be met. For example, the motor had to be able to operate in ambient temperatures that vary from 35° to 125° F; be capable of 12 reversals per minute; produce an output of 1/140 hp at 1650 rpm and have a 200% starting torque of full load; have a no load speed of not more than 1800 rpm; and operate in relatively dusty (coal and ash) locations.

The required motor life was set at 45,000 hours of continuous operation under field conditions. Some of the other requirements were that the motor be capable of operating in any position; all surfaces had to be protected against rust and corrosion from the most severe indoor boiler room atmospheric conditions; the overrun of the motor after de-energization could not exceed 3 seconds under any of the temperatures encountered; motor design had to receive Underwriters' Laboratories approval; cause no radio interference; and be free of brushes, commutators, slip rings and other sliding electrical contacts.

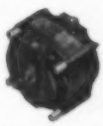
To meet all the requirements set forth by the Perfex Corp., Bodine engineers found it necessary to prescribe a special NCI-12, flange-mounted motor. However, Bodine's wide variety of standard motors —over 3500 in all types and ratings (1/2000 to 1/6 hp)—held the number of cost-increasing modifications to a minimum. If you have a motor application problem, it will pay you to consult Bodine engineers.


REASONS WHY
"During the course of the design of this actuator we set up very rigid specifications and requirements for a motor which would properly power our device. These specifications were submitted to various motor manufacturers of good reputation for design purposes. Your organization was able to supply us with a very satisfactory design at an attractive price and was selected for this reason. We appreciate the good attention your company has given us at all times and are well pleased with the quality of the motor."
Perfex Corporation
Milwaukee, Wisconsin

Over 3500 Standard Bodine Motors (1/2000 to 1/6 hp)

Worm gear speed reducer motor for automatic scales, laboratory apparatus, sign flashers and similar applications.

Series wound motor for adding machines, check protectors, motion picture projectors and similar applications.



Small (2⅜" high), totally-enclosed, capacitor motor—synchronous and nonsynchronous—for instruments and timing devices.

A double worm-gear speed reducer motor — 1/150 h.p. to 1/50 h.p. — for vending machines, plating barrels, etc.

Offered in a variety of types for hand driers, communication equipment, bag closing machines and similar devices.

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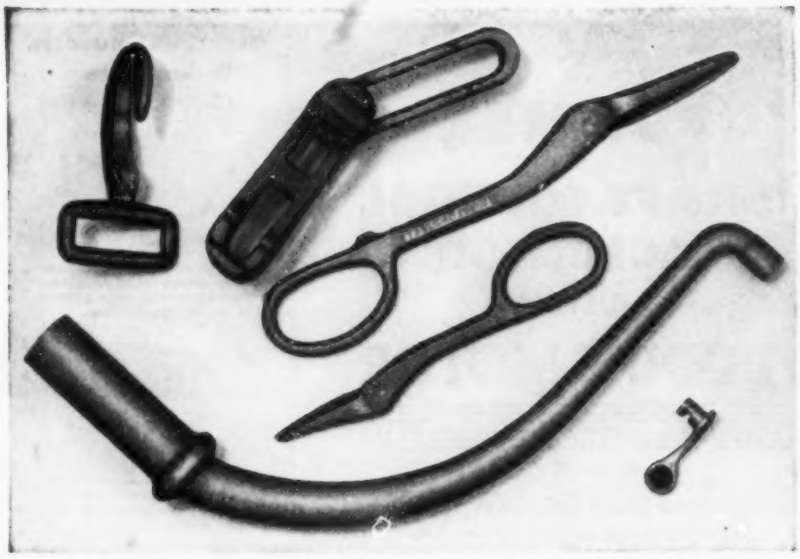

REMEMBER

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DROP FORGINGS

For maximum strength and accuracy of metal parts, Ritco Bright Finish Drop Forgings are outstanding. Smooth and free of flash, they are produced in steel or non-ferrous metals, in weights from ¼ lb. to 15 lbs. It pays to remember Ritco for drop forgings, special fasteners, and regular and heavy head finished body bolts . . . also for machining and grinding.

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Exclusive New England Representatives for Cleveland Cap Screws

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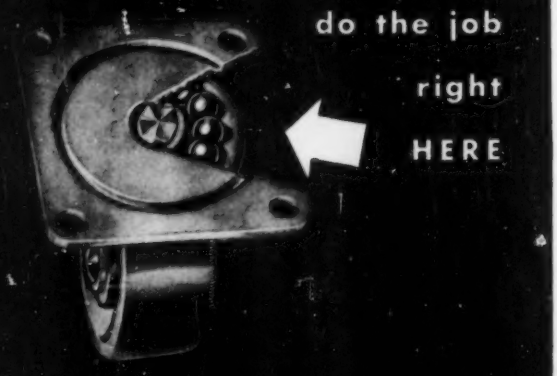
do the job right HERE



Abbott Bearing Balls make casters and other swivel base products turn smoothly and evenly. Every Abbott Ball is ***deep hardened*** with a mirrorlike glass hard finish . . . is shock resistant and performs efficiently under high load factors. Use Abbott . . . *the all round ball.*

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Environment-Free! LIMIT SWITCHES

HERMETICALLY-SEALED

for positive proof against

- **COLD and HEAT** (from −100°F. to +250°F.)
- **Moisture** • **Corrosion**
- **Dirt** • **Oil** • **Ice Jamming**

Here's a dependable limit switch that provides true *Environment-Free* performance. With operating parts fully sealed in an inert gas, this switch will not freeze or jam. It is impervious to moisture, oil, dirt, tampering and misadjustment.

Accuracy with Long-Life

Rigid tests by users have proved that Electro-Snap Switches last longer—while retaining complete accuracy and reliability of operation . . . both electrically and mechanically. They are available with mountings and actuators to fit them to a broad range of uses.

Whatever your use for precision switches, get the facts on the ELECTRO-SNAP Line. Write for *free* Basic Switch and Catalog.

ELECTRO SNAP

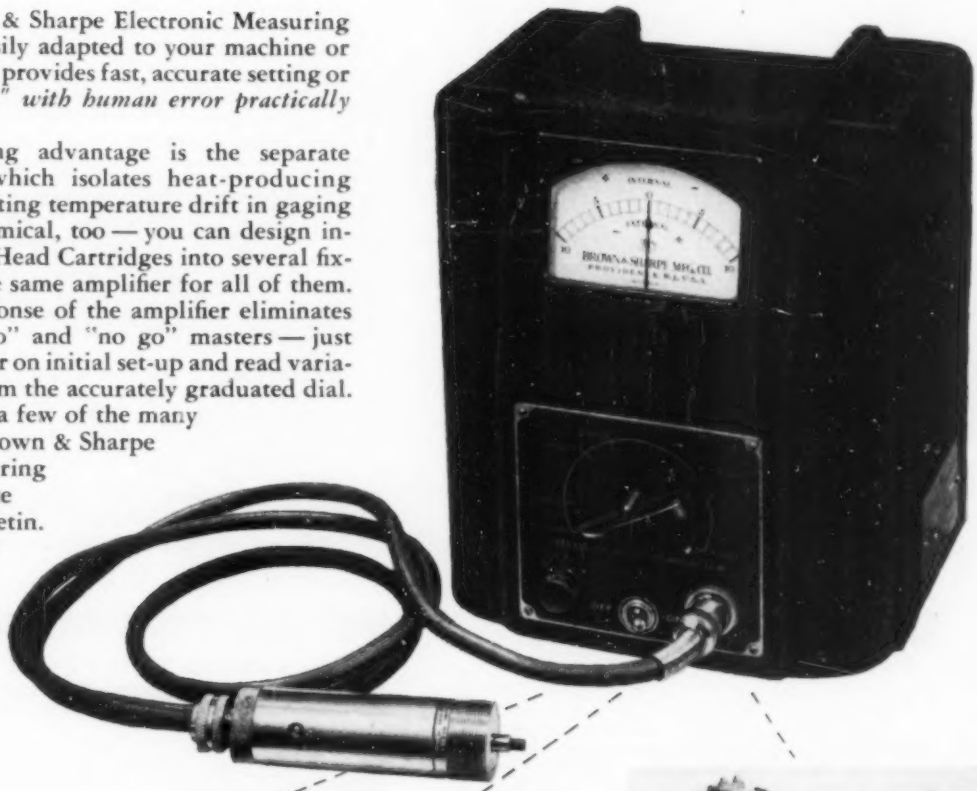
ELECTRO-SNAP SWITCH & MFG. CO.
4218-30 WEST LAKE ST., CHICAGO 24, ILLINOIS

Build *"tenths of tenths"* measuring into your equipment

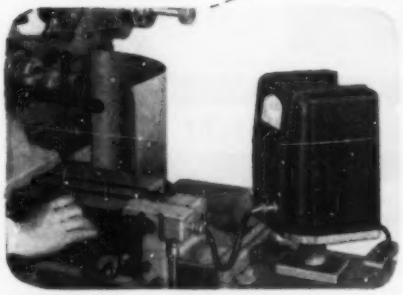
Versatile Brown & Sharpe Electronic Measuring Equipment is easily adapted to your machine or fixture design. It provides fast, accurate setting or gaging to .00001" *with human error practically eliminated.*

An outstanding advantage is the separate amplifier unit which isolates heat-producing elements, preventing temperature drift in gaging units. It's economical, too — you can design inexpensive Gage Head Cartridges into several fixtures and use the same amplifier for all of them. True linear response of the amplifier eliminates the need for "go" and "no go" masters — just "zero" the pointer on initial set-up and read variations directly from the accurately graduated dial.

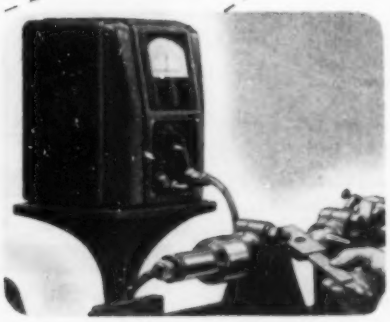
These are but a few of the many advantages of Brown & Sharpe Electronic Measuring Equipment. Write for detailed Bulletin. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.



Brown & Sharpe Electronic Amplifier No. 950 for .0001" to .00001" readings. Gage Head Cartridge No. 953 is plugged in.



Electralign — an application of this precision electronic equipment in Brown & Sharpe's own grinding machines. Permits fast, accurate setting of swivel table for precision grinding straight work or exact tapers after a single trial grind.

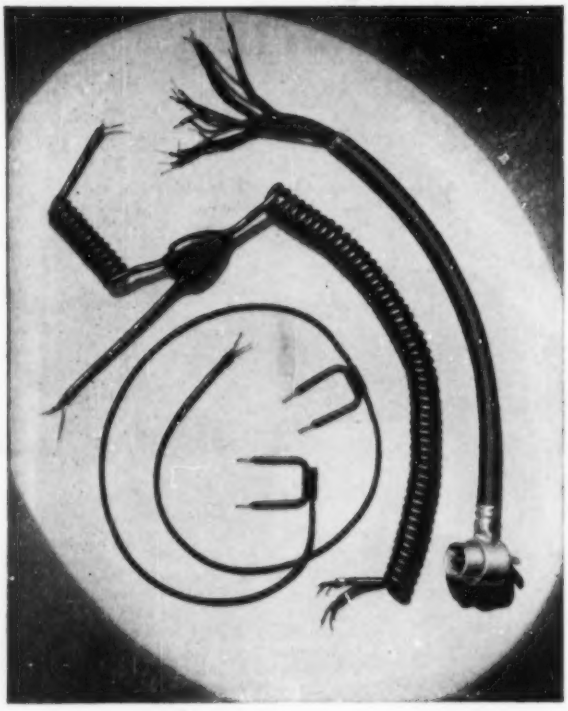


Gage Head Cartridge No. 953 mounted on fixture to measure a fixed gage . . . used with Amplifier No. 950. Standard comparators for external or internal measuring also available.

Special fixture utilizes Gage Head Cartridge and Amplifier to measure internal angle accuracy to ± 1½ seconds independently of bore size and without reference to locating surface.

WE URGE BUYING THROUGH THE DISTRIBUTOR

Brown & Sharpe



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Special cord sets of flexible cord, shielded communications wires and multiple conductor cables, equipped with molded rubber or plastic fittings are among the many quality products offered by Whitney Blake.

If standard molds cannot be adapted to individual applications, Whitney Blake is prepared to design and make special molded junctions and other fittings to provide the water and impact resistance, small size, light weight and protection from tampering so important to many of today's applications.

Whitney Blake has over thirty years experience in the cord set field and more than fifty years in producing well built wires. The close control exercised in the production of Whitney Blake cord and cable and the unusually extensive testing facilities make Whitney Blake Cord Sets completely dependable.

If you have a cord set problem our design engineers will be glad to help you solve it.

WELL BUILT WIRES SINCE 1899

WHITNEY BLAKE CO.

NEW HAVEN 14, CONNECTICUT

ROTATING or STATIONARY ASSEMBLIES
held together EASIER with

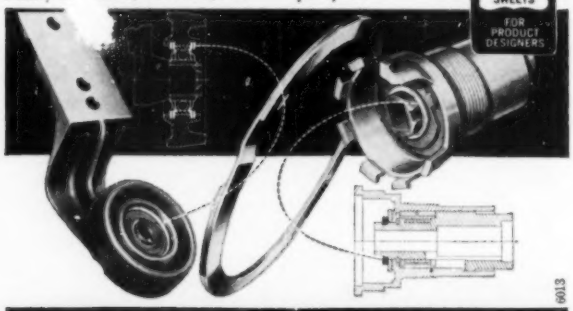
SpirOlox
Retaining Rings

Conveyor roller application at left shows how Spirolox attains neat, compact, simplified design, even on rotating assemblies. Stationary application of lock assembly illustrates how Spirolox can be applied to hard-to-reach places where retaining ring must operate in very confined space. Secret of Spirolox adaptability is patented *two-turn* construction, which makes possible unique locking characteristic... will not jump out of groove. Always provides a uniform shoulder... no lugs, no gap.

FREE DATA BULLETIN
Send blueprint of your retaining problem. Ramsey Co ration, St. Louis 8, Mo.

U. S. Pat. No. 2,450,425 and Foreign Pats. Other pats. pend.

SEE OUR CATALOG IN SWEETS FOR PRODUCT DESIGNERS

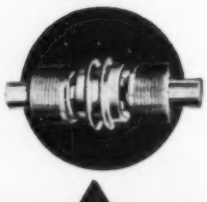


6013

Rotating or Stationary

SPIROLOX—the Better Way to Hold Moving Parts TOGETHER!

Lifts, Carries and Places



Any Size, Shape or Weight

KRANE CAR, built by Silent Hoist & Crane Company, picks up a load of any shape or size, up to ten tons, transports it and spots it accurately, smoothly and safely. ROCKFORD CLUTCHES control the power transmission from its one-man-operated single engine. Let ROCKFORD clutch engineers help with *your* power control problems.

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209 Catherine Street, Rockford, Illinois, U. S. A.

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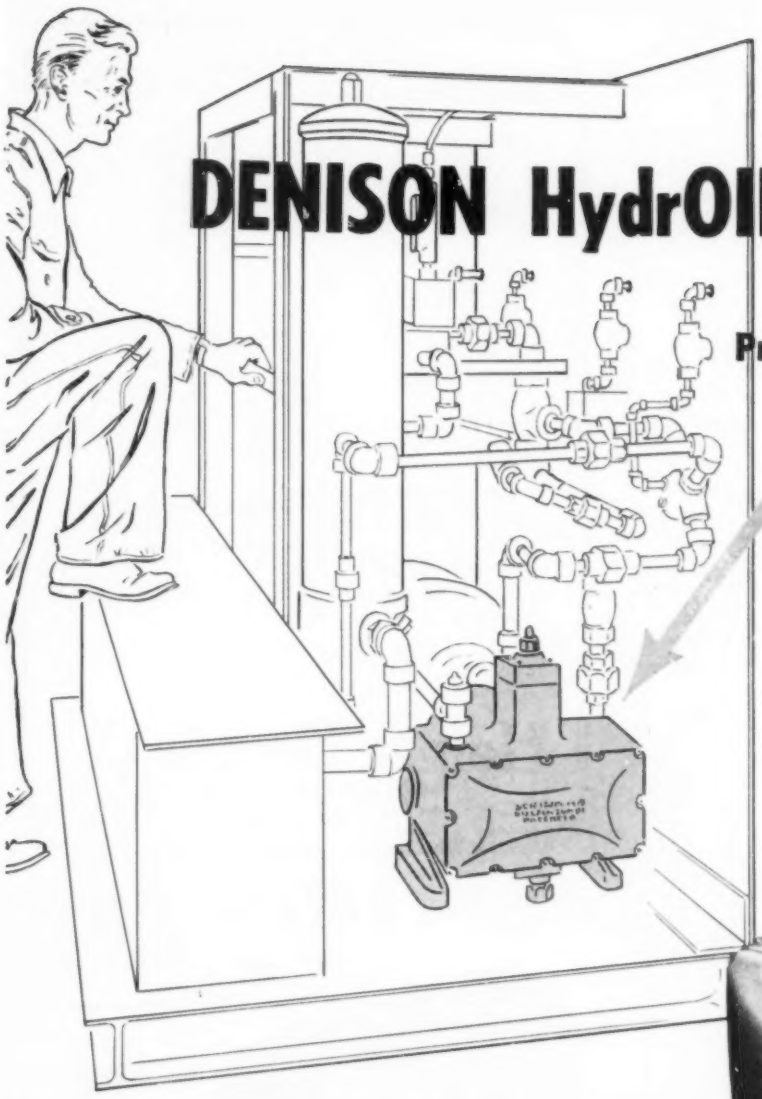
B-W PRODUCTION MAKES IT AVAILABLE

ENGINEERING BULLETIN SENT ON REQUEST

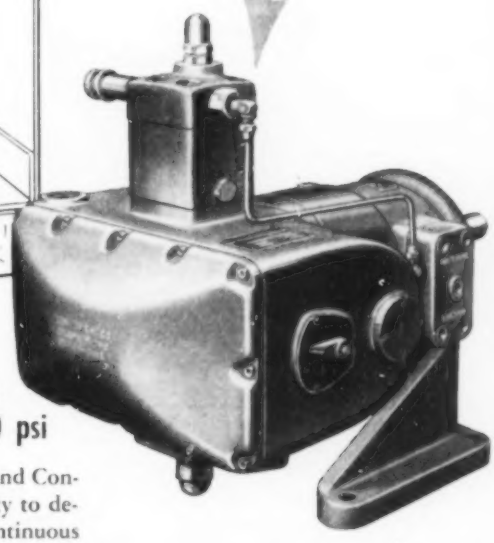
ROCKFORD CLUTCHES

DENISON HydrOILic PUMPS

Prove their EXTRA STAMINA in tough jobs like this



The exclusive design of Denison's axial-piston, constant-displacement HydrOILic Pumps provides exceptionally high volume delivery at all operating pressures—and with oils of widely varying viscosities. They're ruggedly built for long, low-maintenance service. Available in constant and variable volume types—volume control by stem, handwheel, or pressure compensation.



Million-Cycle Test Operations Call for Hydraulic Components That Withstand Hard, Continuous Duty at Pressures of 5000 psi

Three million test loads of 35,000 pounds each — applied at the rate of one every second! That's the job assigned to this high-pressure hydraulic system designed and built in the Fritz Engineering Laboratory, at Lehigh University, for a research project on prestressed concrete beams.

It's a tough job for any hydraulic system — *but it's the kind of job Denison High Pressure HydrOILic Equipment is built to handle.* In addition to the HydrOILic Pump shown above, this test circuit includes a Denison 4-Way Directional Control Valve, a Relief Valve, a Sequence Valve, and a Surge Damping Valve — all designed for 5000 psi duty.

For more than a quarter of a century Denison HydrOILic Pumps and Controls have *proved* their ability to deliver an extra measure of continuous heavy-duty service, under almost any condition. Their rugged, compact design simplifies circuit design and reduces costs.

HydrOILic Pumps offer volume capacities ranging from 2 to 35 gpm . . . HydrOILic Fluid Motors provide torque ratings up to 5585 inch-pounds, or approximately 160 hp. . . HydrOILic Pressure Controls include relief, sequence and unloading types in sizes up to two-inch . . . HydrOILic Surge Damping Valves, made in both industrial and aircraft types, eliminate pressure shock in hydraulic circuits . . . HydrOILic 4-Way Valves are available with seven different types of controls . . . Pilot-Operated HydrOILic Valves meet high-pressure long-cycling needs.

Write for further information on the complete line of Denison HydrOILic Equipment.

The DENISON Engineering Co.
1157 Dublin Road, Columbus 16, Ohio

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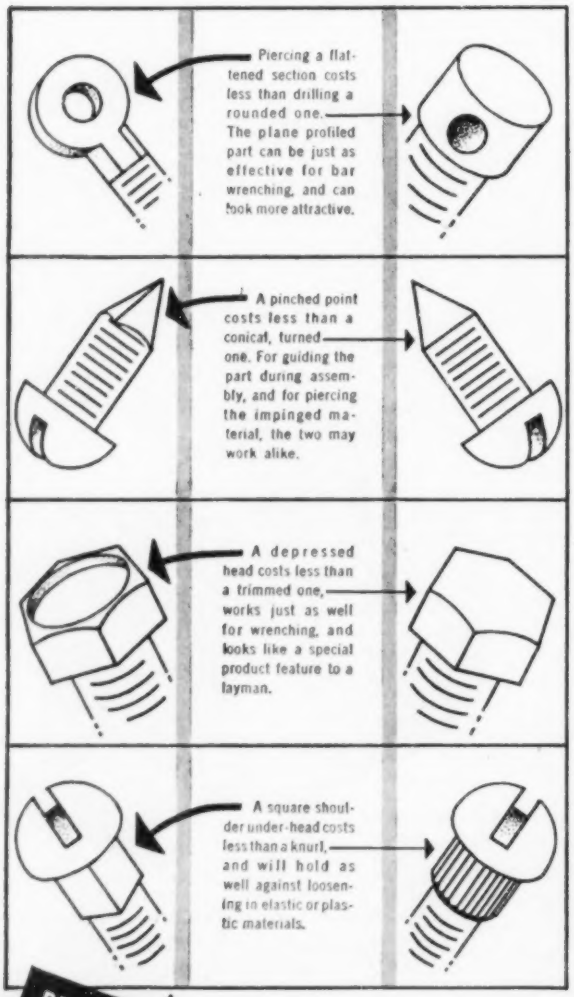
Piercing a flattened section costs less than drilling a rounded one. The plane profiled part can be just as effective for bar wrenching, and can look more attractive.
A pinched point costs less than a conical, turned one. For guiding the part during assembly, and for piercing the impinged material, the two may work alike.
A depressed head costs less than a trimmed one, works just as well for wrenching, and looks like a special product feature to a layman.
A square shoulder under-head costs less than a knurl, and will hold as well against loosening in elastic or plastic materials.

REPRINTS *of this chart are available on request for use in drafting and purchasing departments.*

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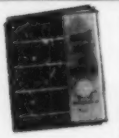

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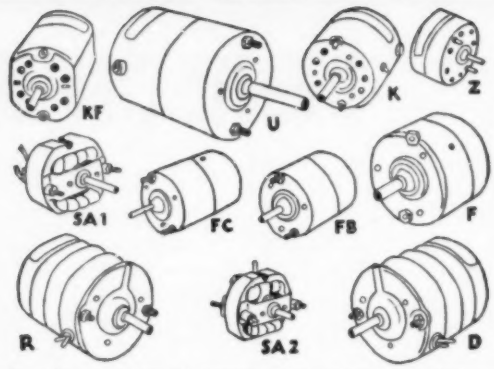

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Type KF saves space in sewing machines and business machines.

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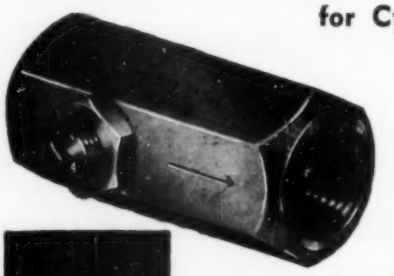
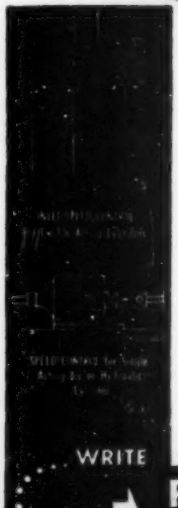
for Cylinder Speed Adjustments OVER A WIDE RANGE IN AIR OR HYDRAULIC USE





The Pneu-Trol Flow Control Valve combines an efficient Stainless Steel FLOATING BALL CHECK which opens and closes at the slightest change in flow direction, with a Vernier Type VARIABLE NEEDLE ORIFICE adjustment in a compact control which has widened air and hydraulic cylinder application by providing precise control of cylinder action. Modifications of the Pneu-Trol Valve are available as Plain Check, check with Fixed Orifice (orifice drilled by customer in the Standard Check Valve), Needle Valve and Velocity Limiting Check, as illustrated at left. All Pneu-Trol Valves are made from bar stock in brass (up to 1000 psi) or steel (5000 psi) or other body metals to your specifications. All internal parts are Stainless. All valves available in 5 sizes—⅛", ¼", ⅜", ½", and ¾".

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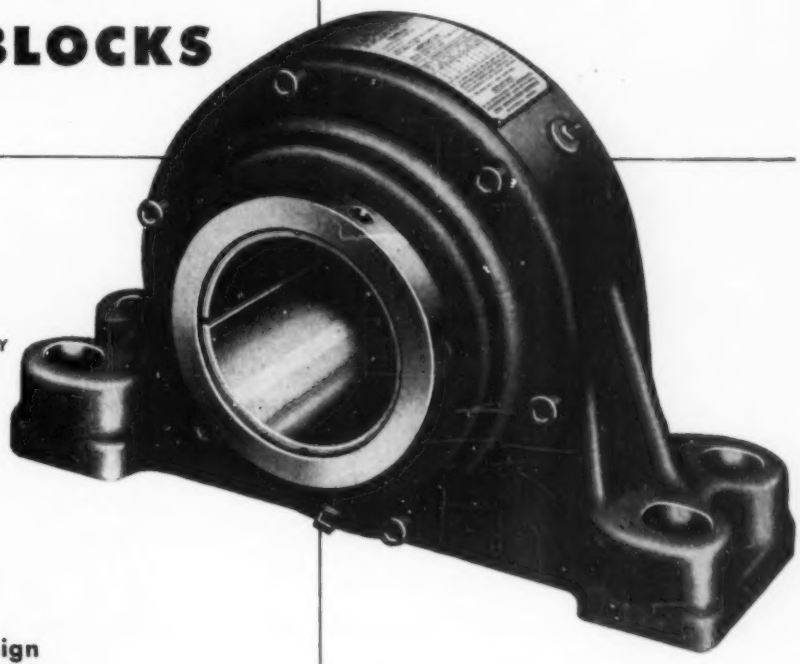
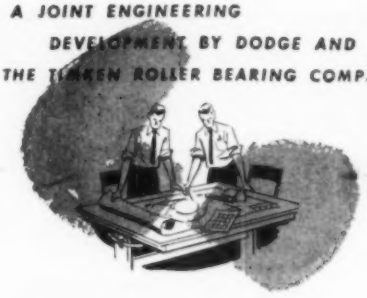


A JOINT ENGINEERING DEVELOPMENT BY DODGE AND THE TIMKEN ROLLER BEARING COMPANY



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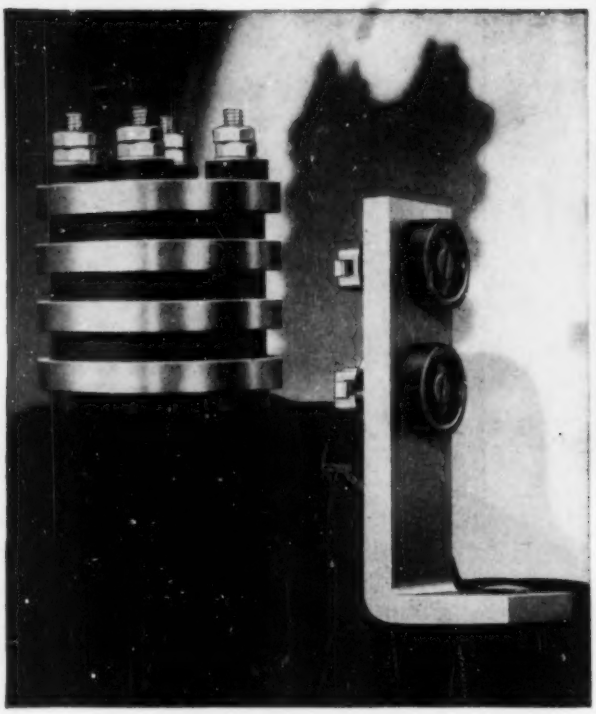

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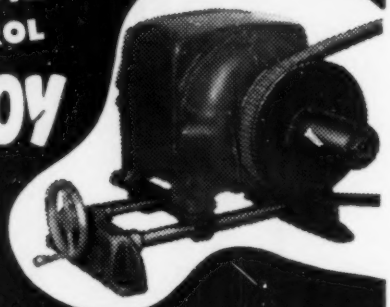

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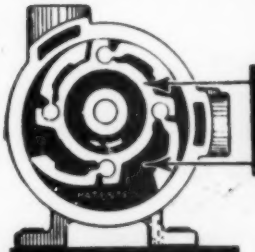

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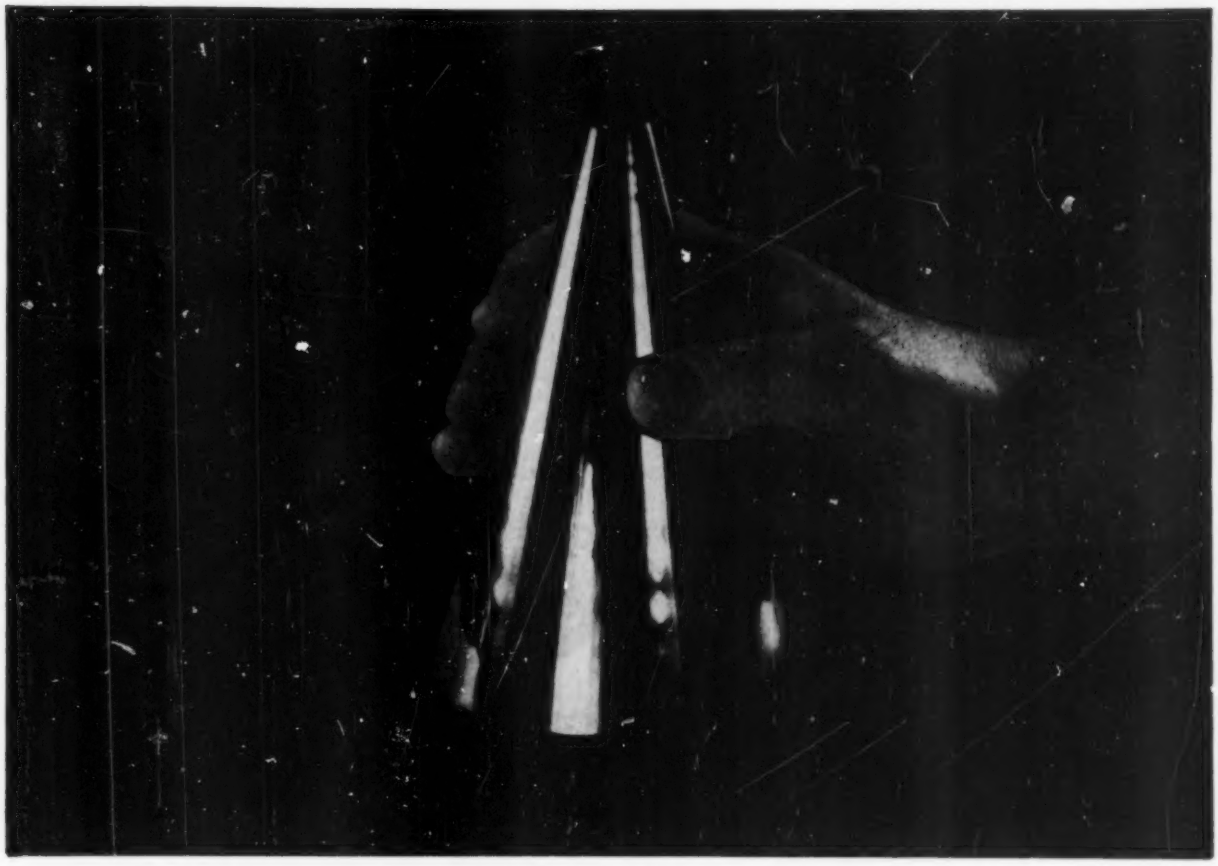

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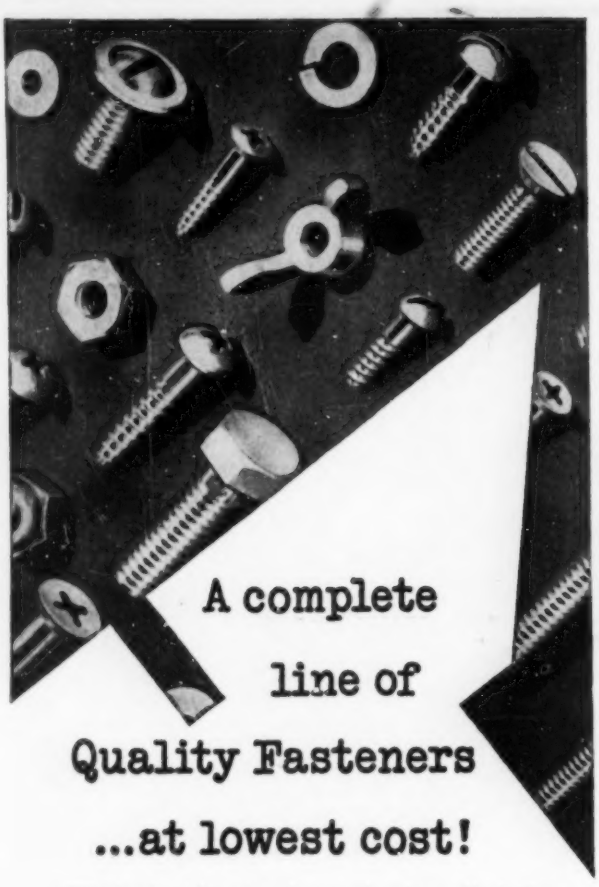

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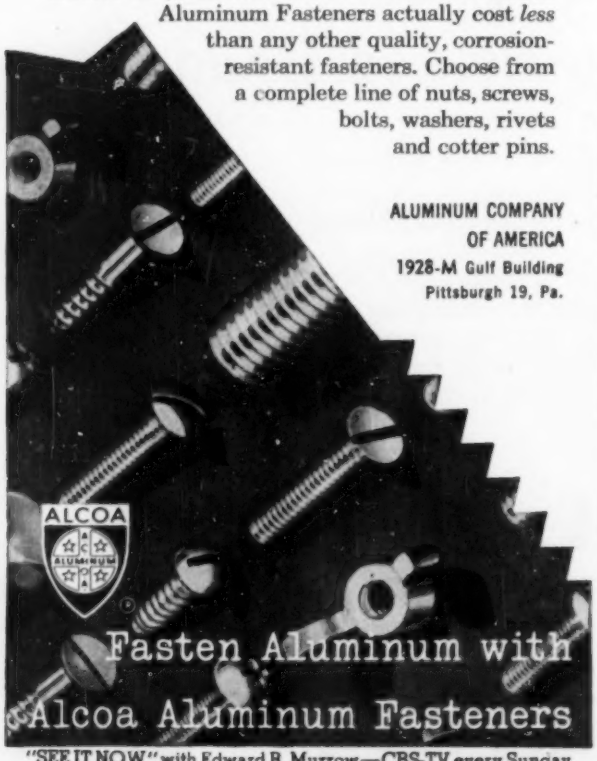

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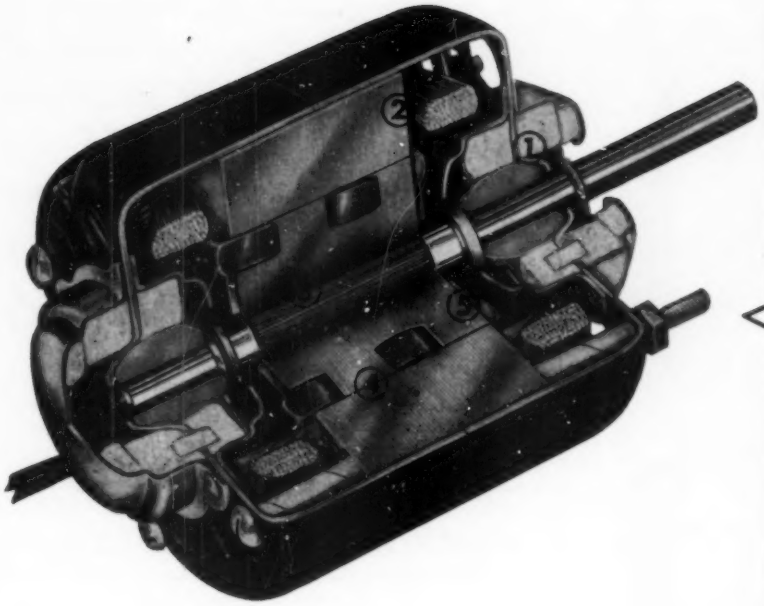

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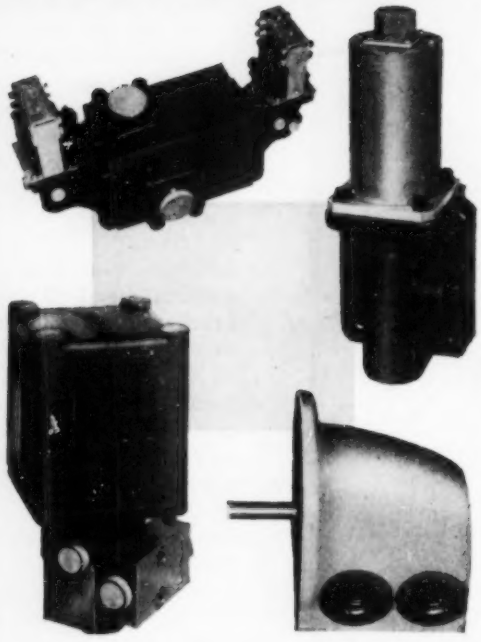

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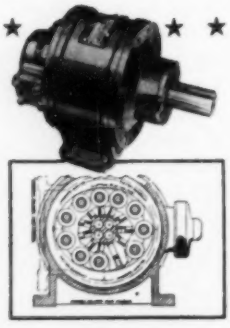

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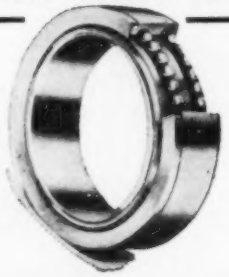

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For Parts that must be

TAKEN OFF–PUT BACK–BUTTONED TIGHT

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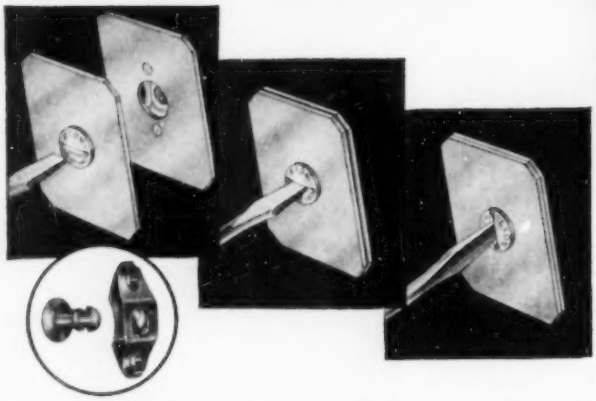

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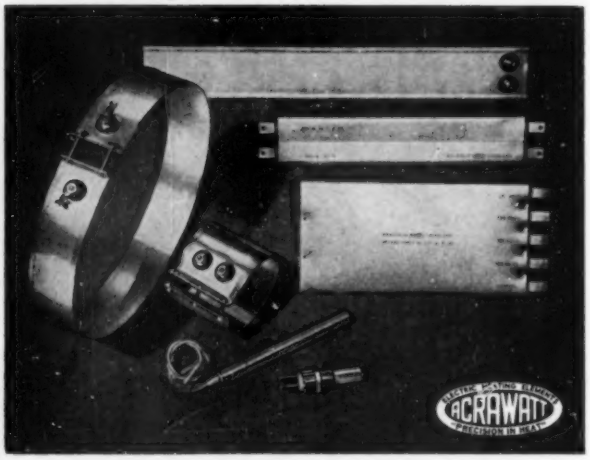

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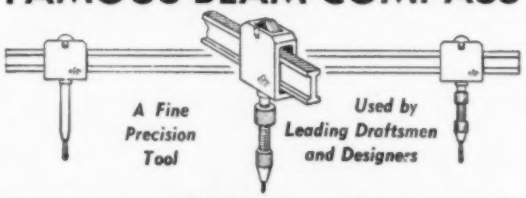

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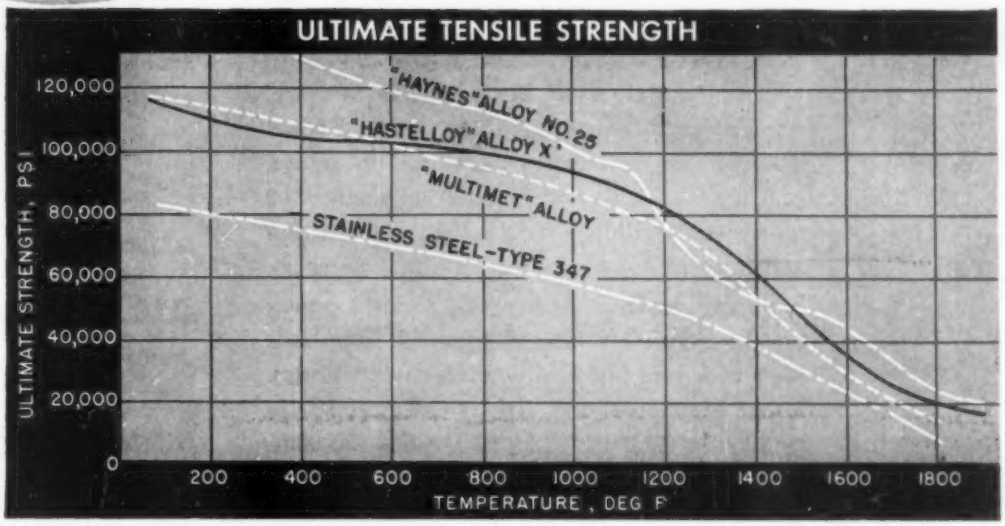
Good Casting Characteristics



The excellent high-temperature properties of HASTELLOY alloy X—a new material that contains iron, nickel, chromium, and molybdenum—make this alloy a good choice for aircraft sheet-metal parts, such as cabin heaters, tail cones, and collector rings. It is also being tested for aircraft nozzle vanes, both precision-investment-cast and fabricated from sheet. In addition, it is designed for high-temperature applications in the chemical, petroleum, metal-producing, and heat-treating industries.

HASTELLOY alloy X has a relatively low content of strategic metals. Tests made so far indicate that alloy X has high-temperature properties comparable to those of other alloys containing a higher percentage of strategic metals (see graph).

The new alloy is available as sheet, plate, bars, wire, and precision-investment castings. For additional properties data, write to our General Offices in Kokomo, Indiana, for a copy of the new booklet "HASTELLOY Alloy X."

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TRADE-MARK
alloys

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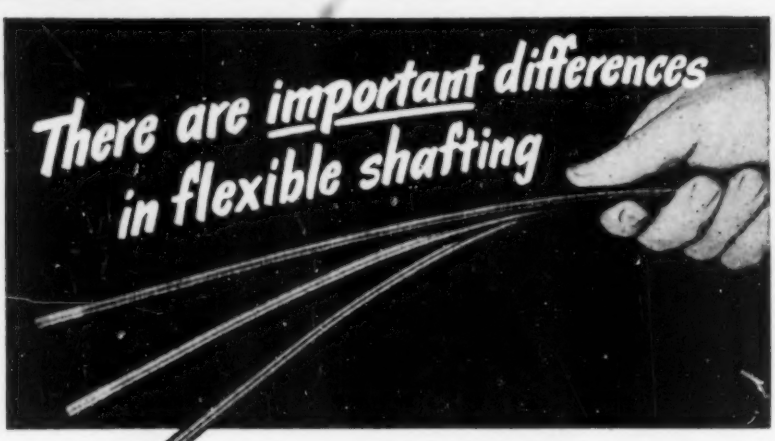

...take the question of transverse flexibility

Tranverse flexibility refers to the ease with which a flexibile shaft lends itself to bending. As the illustration shows, three shafts of equal diameter, and similar in outward appearance, can be made with widely differing degrees of transverse flexibility. The design, construction and material used account for the differences.

Extensive research and product development has enabled S.S.White to establish standards for a wide range of flexible shaft characteristics. These standards are strictly maintained in production to assure you of getting the characteristics you specify—an important factor in determining the success of any flexible shaft application.

Take advantage of the help and assistance of experienced S.S.White engineers in working out your flexible shaft applications. They are trained to *know* the differences in flexible shafting and are well qualified to recommend the flexible shaft combination best suited to your needs. Their cooperation entails no obligation —so call them in today.

WRITE FOR THIS 256-PAGE FLEXIBLE SHAFT HANDBOOK

It has complete information on how to select and apply flexible shafts. A copy will be sent free if you ask for it on your business letterhead.

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DENTAL MFG. CO.
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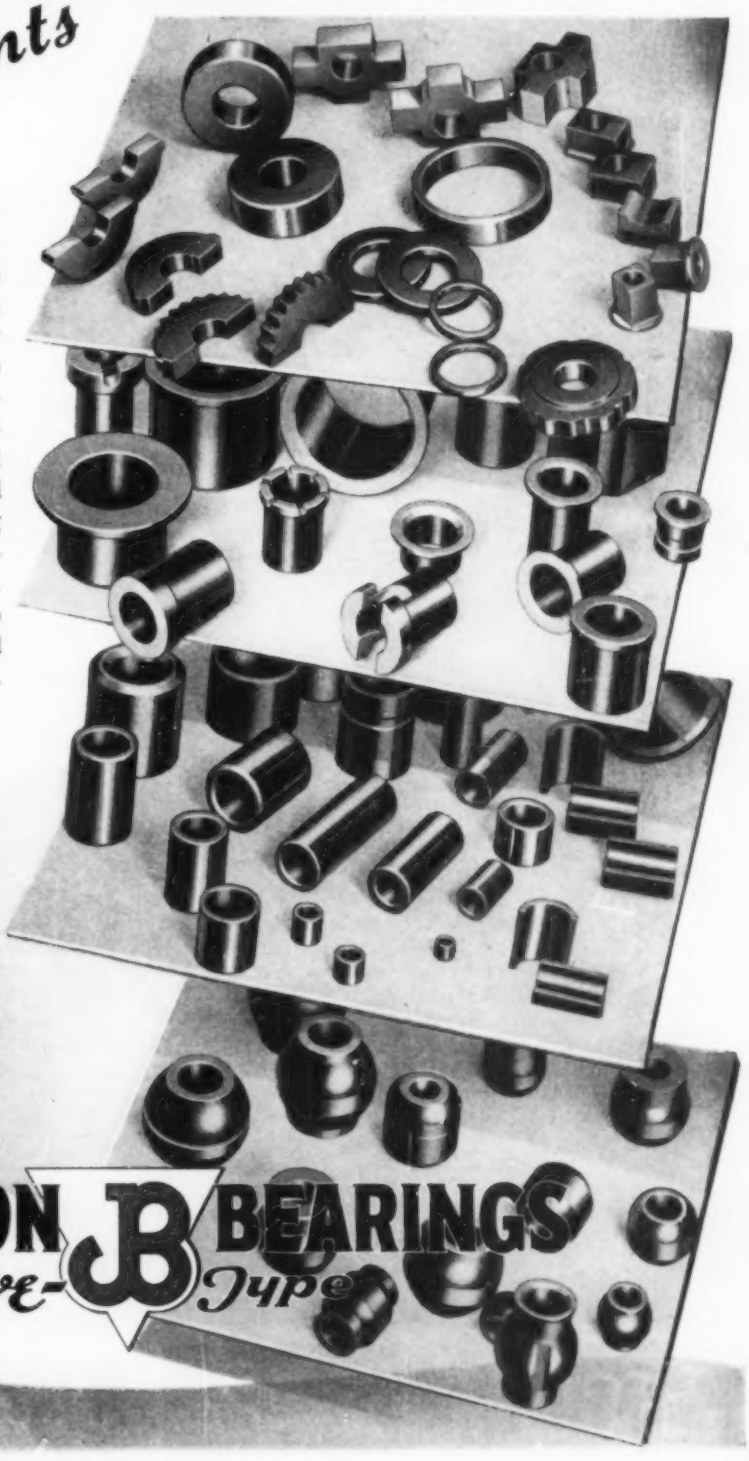

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Many Sizes of plain, flanged and self-aligning bearings may be ordered from stock.

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Sleeve-Type

Dependable performance for aircraft sprayers . . . with

STOW flexible shafting!

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According to Mabry I. Anderson, of Mississippi Valley Aircraft Service, manufacturers of the Aero Mist Spray System, "Your shafts have never failed—even though they've already given us thousands of hours of *trouble free* service".

Consider STOW flexible shafting for your next Power Drive or Remote Control application. Our engineering department will be happy to work with you. No obligation, of course.

◀ ***Write today*** for your free copy of Bulletin 525 containing complete engineering data on STOW flexible shafting.

See us in SWEET'S CATALOG

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TINY **but MIGHTY!**

SKINNER STAINLESS STEEL SOLENOID VALVES

. . . Another case of "a good thing in a small package"! Users are amazed at the ruggedness and unusually large capacity of Skinner Valves—they're tiny but mighty, with a standard range for gaseous or liquid media from 5 to 250 p.s.i., and special from 5 to 850 p.s.i. Their soft insert seat prevents leakage and positive action is assured by spring loading. Skinner Valves may be used in any position, with pipe connections furnished to suit specifications. Power consumption is 10 watts max. Special coils for high humidity or high temperature applications can be supplied. Standard models are approved by Underwriters' Laboratories. *Write for Bulletin No. 501.*

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ENDS TAPPING TROUBLES

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Ultra Precision THREAD-CUTTING BROACHES deliver these advantages:

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- Feed the chips out of the hole.
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- Replace standard taps in most sizes.

SHEARCUTTER TOOLS COST LESS IN THE LONG RUN

These ultra-scientific cutting tools are used by practically every large manufacturing company in the U.S.A. Constant repeat orders prove their merit and value.

Patent Warning: All Shearcutter Tools are protected by U.S. and Foreign Patents, received, pending or applied for.

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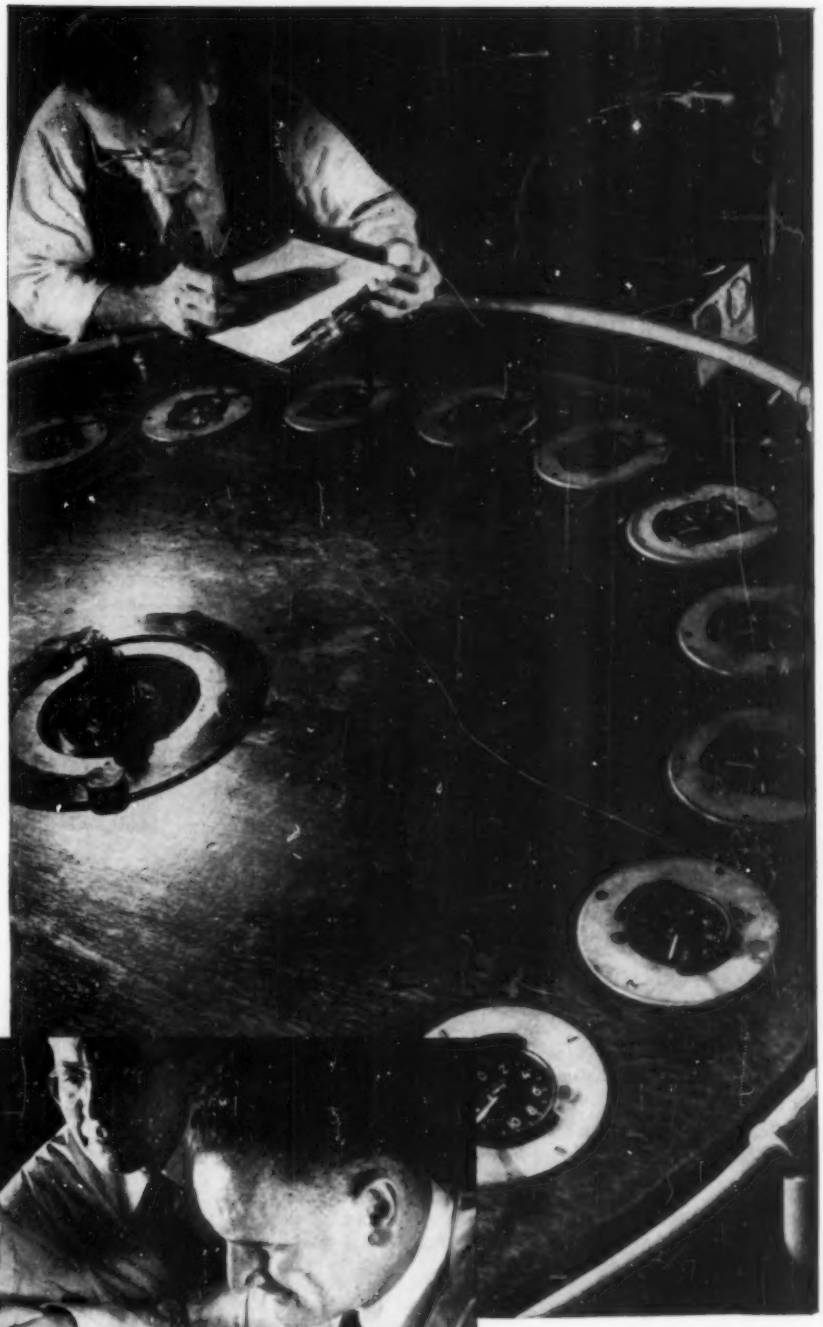
While our manufacturing divisions are engaged largely in defense production, the Kollsman Instrument Corporation welcomes the opportunity to apply its research experience to the solution of problems in instrumentation and control.



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SUBSIDIARY OF *Standard* COIL PRODUCTS CO INC.

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COMPARE THIS HIGH TORQUE MOTOR WITH ANY OTHER OF ITS SIZE AND PRICE RANGE

Bristol "Circle B" synchronous timing motors provide exceptional power for their size. They are available for 25, 115, or 230 volts, 50-60 cycles. Rotation clockwise or counter-clockwise as specified. A wide range of standard and special output shafts is available. Look at these features!

POWER—Standard models of the "Circle B" Motor now available range up to 16 in. oz. torque continuous duty and 84 in. oz. torque intermittent duty at 1 r.p.m.

POSITION—This versatile timing motor is precision-built to operate perfectly in any position. No vibration or noise. Efficient Lubrication System.

COMPACTNESS—The "Circle B" Motor is compact—fits into a 2" circle, and is only 1 17/64" deep.

SPEEDS—This motor is made in a wide range of standard speeds—from 1/6 r.p.m. to 1800 r.p.m. Can be made on order for other speeds.

OUR expert engineering staff is available for the development of special motors, or for application to special uses. We will welcome the opportunity to discuss and analyze your particular problem, either at our plant in Old Saybrook or in your own offices. Write for data and price sheets.

Bristol Motor Div. of Vocaline Company of America, Inc.
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A HUNDRED WAYS
to keep the liquid level where you want it

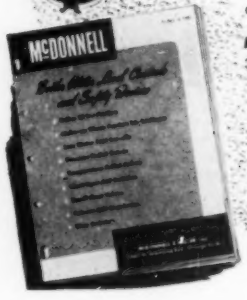
McDONNELL float-operated devices are made in more than a hundred forms to respond to liquid level movements.

They operate valves to maintain constant levels—constant heads. They operate switches to start and stop pumps, maintain high or low levels, sound high and low level alarms . . . perform just about every imaginable function involving liquid level control.

Pump controller and low level switch—one of many

A wide variation of working pressures, liquid feeding capacities, electrical ratings, and circuits are covered by the many types. The broad range of types and materials make them adaptable to practically all services and design requirements.

Ask for catalog which suggests the many adaptations. Don't manufacture your own float-operated unit until you have gone over the McDonnell line.



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"Our country's strength is created by the responsibility and solidarity of individual citizens in a self-chosen government and economy. It can—and must—be perpetuated against all who seek to undermine it. The men and women who invest regularly in United States Defense Bonds are contributing to our national integrity and to the traditions of personal independence so characteristic of a free people."

Every pay day, 6,500,000 employed men and women . . . "are contributing to our national integrity and to the tradition of personal independence . . ." by the systematic purchase of United States Defense Bonds.

How important is this contribution to national economy and personal security? Let's look at a few figures.

- the cumulative purchases of 6,500,000 Payroll Savers add up to $130,000,000 per month.
- the number of individual E Bonds sold in 1951 totaled 68,069,000 pieces—8% more than in 1950.
- purchases of $25 and $50 E Bonds—the denominations popular with Payroll Savers—were greater than the sales of $500 and $1,000 E Bonds.
- monthly redemptions of unmatured E Bonds during each of 9 months (April to December, 1951) were less than 1% of the amounts outstanding.
- the *cash value* of Series E Bonds held by individuals on December 31, 1951, amounted to $34,727,000,000—$4.8 billions more than the cash value of Series E's outstanding in August, 1945.

That Americans have built personal security and a reservoir of purchasing power exceeding $34.7 billions is due in no small measure to the patriotism and foresight of men like Mr. Taylor and other leaders of industry who have made the Payroll Savings Plan available to their employees.

For help with your Payroll Savings Plan, phone, wire or write to Savings Bond Division, U.S. Treasury Department, Suite 700, Washington Building, Washington, D. C.

The U.S. Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

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Koiled Kords

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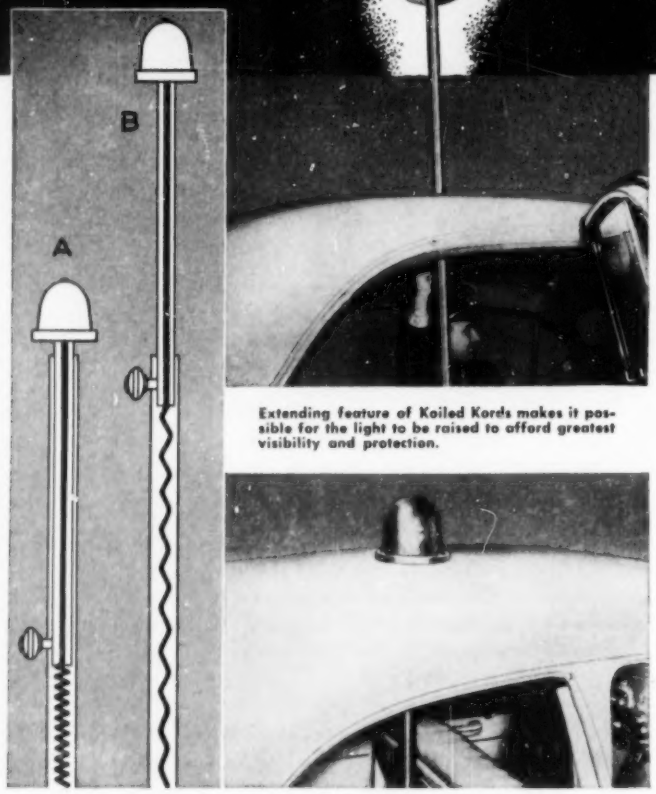
APPLICATIONS



Line drawings show position of Koiled Kord (A) retracted and (B) extended within light standard.

Extending feature of Koiled Kords makes it possible for the light to be raised to afford greatest visibility and protection.

Normal position of light is snugly fitted to top of car. In this position, the Koiled Kord is retracted within the standard.

The telescopic emergency lights made by McDonald and Arneson, Vallejo, California, demonstrate an interesting application of the expanding and retracting abilities of Koiled Kords.

In this case, by the use of a combination of straight and Koiled Kord, one tube can telescope within the other without interference from the cord which is contained in the outer tube.

Write for illustrated bulletin showing many uses for Koiled Kords.

*TRADE MARK

Koiled Kords INCORPORATED

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Use liquid cement?

Try AMBROID

Like the Spider's sticky web, doing business a long, long time, and still the best adhesive of its type.

HERE'S WHY: Ready-to-use
Fast setting Transparent
Waterproof Flexible
High tensile strength
Faster ultimate joint-strength

Ambroid is unsurpassed for speedy assembling, ideal for manufacturing processes in radio, electrical, telephone and electronic work. High dielectric qualities, corrosion resistant. Remains stable over wide temperature range. Non-toxic.

Immediate shipment—2 oz and 4½ oz tubes, pints, quarts, and one gallon cans, drums. Order from your supplier or write direct for Data Sheet.

Inquire about special Industrial adhesives to suit your needs

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304 Franklin Street
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How Christmas Seals help save lives

Successful methods of treatment make it more important than ever to find the 150,000 "unknown" cases of tuberculosis—and to find them early.

Mass X-ray campaigns to find TB in time are part of the work your Christmas Seal dollars help support.

Remember, no one can be "cured" until treated . . . and no one can be treated until the disease is discovered.

Send in your contribution today.

Buy Christmas Seals

Because of the importance of this message, space contributed by **Product Engineering**

For the Production Engineer's Notebook—

Ideas for Welded Design

Product engineers, even the geniuses among them, find that the formula, "1% inspiration, 99% perspiration,"* pretty regularly applies.

Perspiration in design is brought about by the inevitable conflict between operating function—how well the part will do its job—and such other important factors as sales appeal, serviceability, and manufacturing methods.

What we are all striving for is to apply welding most economically. We in LINDE stand ready to help the product engineer in the applications of welding methods wherever we can. Sometimes economies in production come from a substitution of welding for more expensive methods, but often just a small change in design or practice reduces the cost of present welding operations.

Pointers on welded design leading to production economies.

Use the process that gives the greatest total economy.

Design for down-hand welding where possible. But locate welds so as to minimize handling.

Mechanize welding. Weld as many joints simultaneously as possible.

Make minimum dimension changes when making different sized models.

Reduce the number of parts. But sometimes it is better to increase the number of parts and cut rejects in intricate castings or formings by welding together simple forms.

Use standard shapes and easily formed sections.

Pointers on welding processes leading to production economies.

HELIARC welding: used for most metals—argon protects weld puddle. Minimizes cleaning and finishing costs. Manual, mechanized, and semiautomatic welding. Latter ideal for work on sheet materials with irregular contour.

Sigma welding: consumable electrode supplied as continuous coil of wire. Makes clean, smooth welds in practically all commercial metals at high rates of deposition, low costs, and high weld zone cooling rates.

UNIONMELT welding: high speed process for making deep-penetrated welds—butt, tee, lap fillets, plug—in most ferrous and non-ferrous metals. Usually mechanized, but also applicable by hand with flexible welder.

Take advantage of other economies that are inherent in such oxy-acetylene processes as flame-cutting, welding, surfacing, hardening. For more information on any of these processes call or write the nearest LINDE office today.

* "Genius is 1% inspiration and 99% perspiration," credited in GOLDEN BOOK, April, 1931 to a newspaper interview with Thomas A. Edison.

LINDE AIR PRODUCTS COMPANY
A Division of Union Carbide and Carbon Corporation
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In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto
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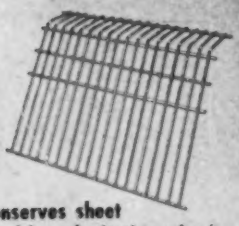
wire-forming ingenuity has licked many a tough problem for engineers, production and purchasing men.

how can we help you?

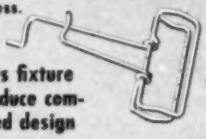
Tell It To Titchener

Perhaps Titchener can solve your problem with wire. Send prints —describe requirements in a letter. Confidential. *No charge for our suggestions.*



Conserves sheet steel by substituting wire

This ice cube deflector originally consisted of sheet steel, woven wire and a steel frame. Sheet steel shortage loomed. Told it to Titchener. Titchener designed rack using one size of wire throughout. No sheet steel needed — sturdier — costs less.



Invents fixture to produce complicated design

Manufacturer required this intricate two-piece clamp. Ran into production difficulty. Told it to Titchener. Titchener built a special power-forming fixture which coils wire around itself — thousands of precision-made clamps now produced at high speed, low cost.

Combines motor mount and guard to reduce cost

Manufacturer requested quotation on wire guard to slip over motor mount. Titchener suggested combining guard and mount in a single assembly. This simple one-piece construction slashes material, production and assembly costs.

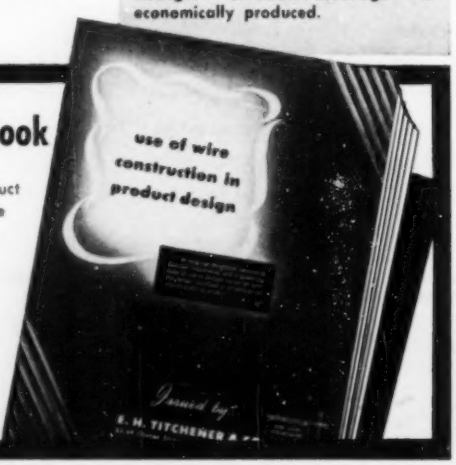
Replaces casting with welded wire —eliminates breakage

Stove manufacturer experienced high breakage of his cast iron burner grates. Told it to Titchener. Titchener design shown here is lighter — stronger — eliminates breakage — is economically produced.

Send for FREE Handbook

"Use of Wire Construction in Product Design" — an illustrated 20-page technical handbook sent free to engineers, purchasing agents and production men. Write for your copy.

E. H. Titchener & Co.
103 Clinton St.
Binghamton, New York



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Northeastern Engineering, Inc. is a young, progressive company that is offering excellent positions to qualified engineers. If this advertisement interests you, send us a resume and salary requirements, along with a photograph.

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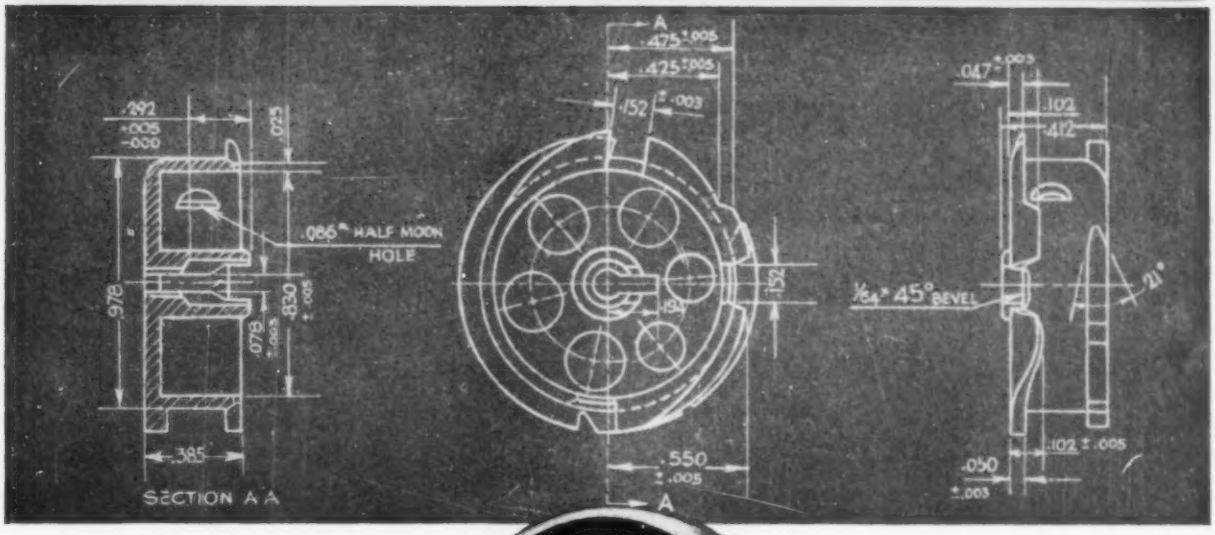
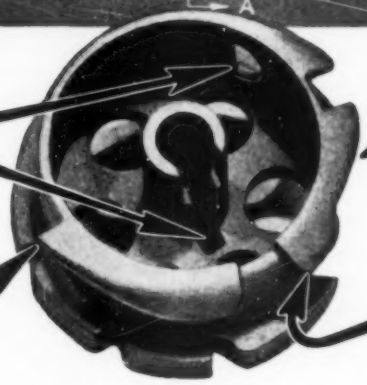
MISCO *Precision* CASTINGS

CARBON AND STAINLESS STEEL

CAST TO MICROMETER TOLERANCES





COSTLY BROACHING operations eliminated. Precision Casting these normally difficult slots actually lowers production costs by lightening the part.

HAND FINISHING of irregular surfaces and contours is eliminated or reduced to polishing rather than costly hand grinding.

SHARP CORNERS offer no problem when pressure casting in ceramic molds. Both inside and outside corners cast to .008" radii.

UNDER CUTS are formed by free flowing mold material. Areas impossible to reach with a tool are cast to micrometer tolerances.

Eliminate Expensive Machining

The Misco Precision Casting held to tolerances of ± .003" per linear inch needs only minor finishing operations. Tooling cost for Misco Precision Casting is extremely low and large scale production can be scheduled for quick delivery. Misco Precision Castings are available in high strength hardenable steels as well as austenitic stainless types such as 18-8. The range offers maximum resistance to heat, corrosion and wear. Let our engineering department assist with your design, production, and material problems.

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Heat and Corrosion Resistant Alloys

One of the World's Pioneer Producers of Heat and Corrosion Resistant Alloy Castings

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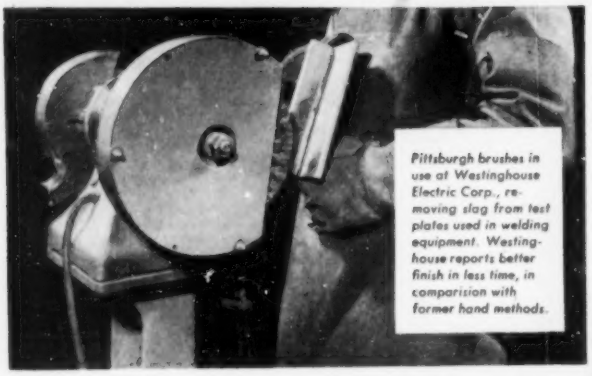

Pittsburgh brushes in use at Westinghouse Electric Corp., removing slag from test plates used in welding equipment. Westinghouse reports better finish in less time, in comparision with former hand methods.

Replace hand finishing with power-driven Pittsburgh Brushes for

Better Cleaning
Lower Labor Costs
Fewer Rejects

— as these companies did:

Removal of imbedded slag in welding test plates formerly was done by hand at the Westinghouse Electric Corp., Trafford, Pa., using a wire brush and welder's hammer. Pittsburgh brushes, powered by a direct-drive ½ h.p. motor, now remove more slag in less time, and produce a better finish. In addition, Westinghouse reports their Pittsburgh brushes "stand up better than average in use."

Complete cleaning of dried concrete, rust and scale from steel frames used in concrete forming is essential prior to re-using the forms. Pittsburgh wire brushes were installed at the Universal Form Clamp Co., Chicago. Working on a conveyor-fed machine, the Pittsburgh brushes now remove all foreign material at a rate of 50 pieces per hour, replacing former laborious hand brushing and scraping.

De-scaling preheated bar stock at the Dominion Forge & Stamping Co., Ltd., Canada, was formerly done by hand scraping. This never did a complete job, and inclusions resulted which produced defective forgings. Pittsburgh brushes, on specially-designed machines, now do the job, and have "increased efficiency, decreased the amount of scrap, improved work quality, and saved labor."

WRITE TODAY FOR FREE BOOKLET!

Write today for a free copy of our booklet that shows, through actual case histories, how Pittsburgh cuts brushing costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W-6, 3221 Frederick Avenue, Baltimore 29, Maryland.

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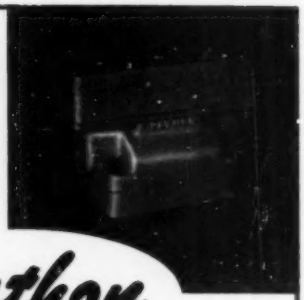
HYDRAULIC VALVES



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• WRITE today for literature covering Pathon's new Solenoid Controlled Pilot Operated Hydraulic Valves, Bulletin No. 15 and/or Hydraulic Cylinders, Bulletin No. 17.

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Engineers

Roy W. Lessard, Assistant Chief of Design. Has had extensive aeronautical design and structures experience with many leading aircraft manufacturers and is part of the Fairchild engineering team.

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HAGERSTOWN, MARYLAND

PORTER-CABLE *reduces weight and cost with* PARKER DIE CASTINGS —

PORTER-CABLE, one of the best known names in the power tool field, is using Parker Aluminum Die Castings on their No. 106 Finishing Sander. Again Die Castings have proved to be the most economical production method, minimizing the need for machining operations. In all portable tools, weight is an important consideration. Here, aluminum die castings were selected for the motor housing, cover and handle in a successful effort to keep weight at a minimum. Parker can produce quality castings for you, too—in aluminum, brass, bronze or zinc. Submit your next requirements to Parker. Our engineers can help you in the earliest stages of your product development.

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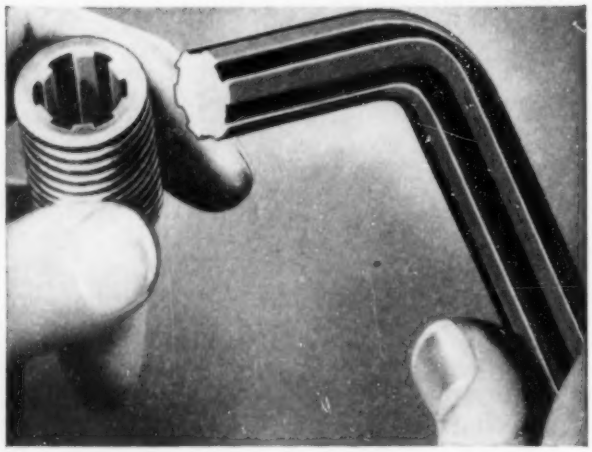

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CONTINUED ON PAGE 420

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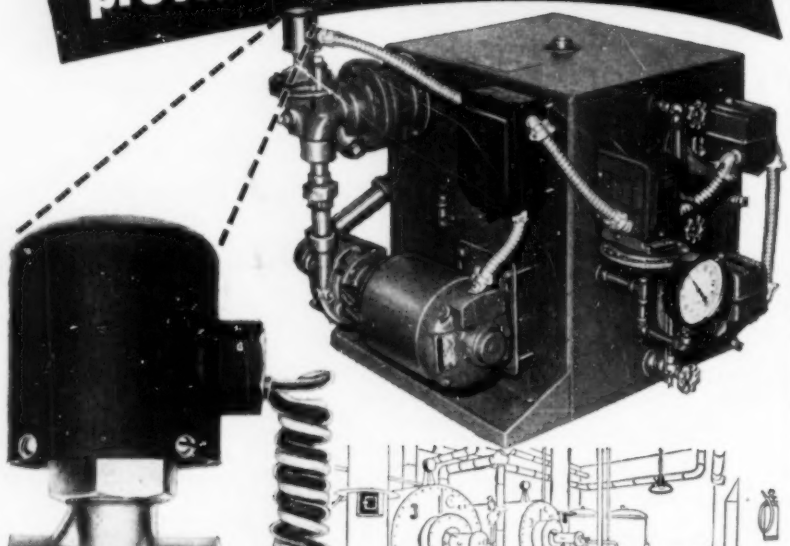

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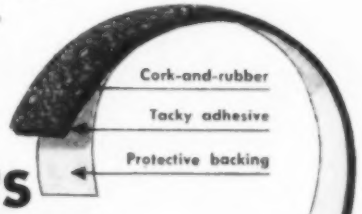

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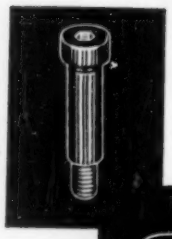
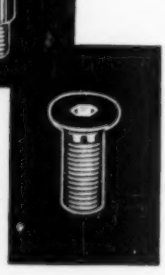
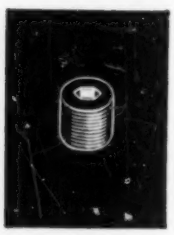


Stripper Bolt



Flat Head Cap Screw



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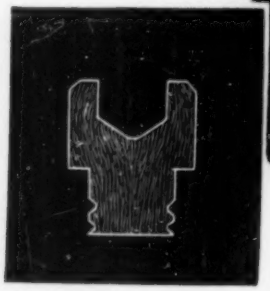
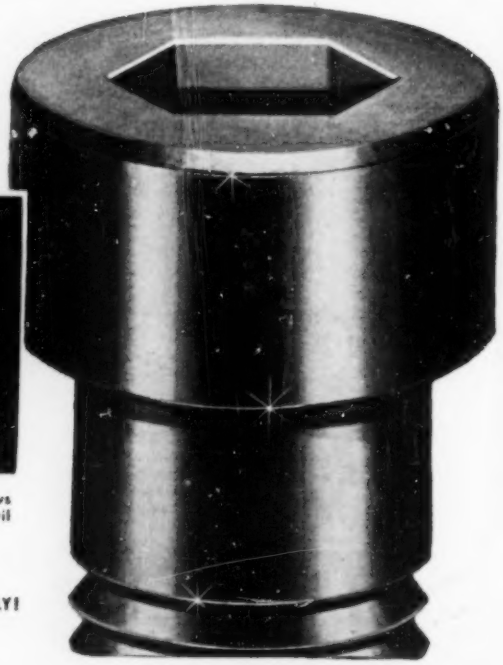


Actual cross-section photo shows structural continuity of Blue Devil cap screw from body to head.



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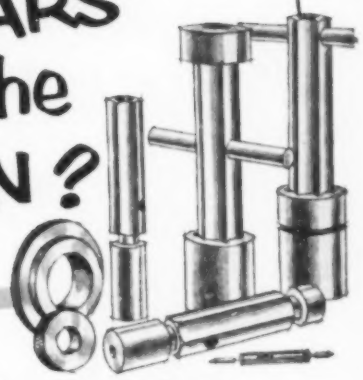

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Normal life of your cutting tools and wear parts can be multiplied 3 to 10 times by this accurate, simplified method of chrome plating right in your own shop. Chromaster deposits chrome with positive uniformity yet the average job takes only 3½ minutes.

A Chromaster for every shop

Model A-20 (shown here) is a 20-amp, bench-mounted unit for the gage room or tool crib; plates up to 10 sq. in.

Model A-50, 50-amp, bench-mounted unit for larger shops in plating of cutting tools. Plates up to 25 sq. in.

Model A-250, 250-amp, floor-mounted unit for production plating of small parts in greater quantities or larger parts with areas up to 125 sq. in.

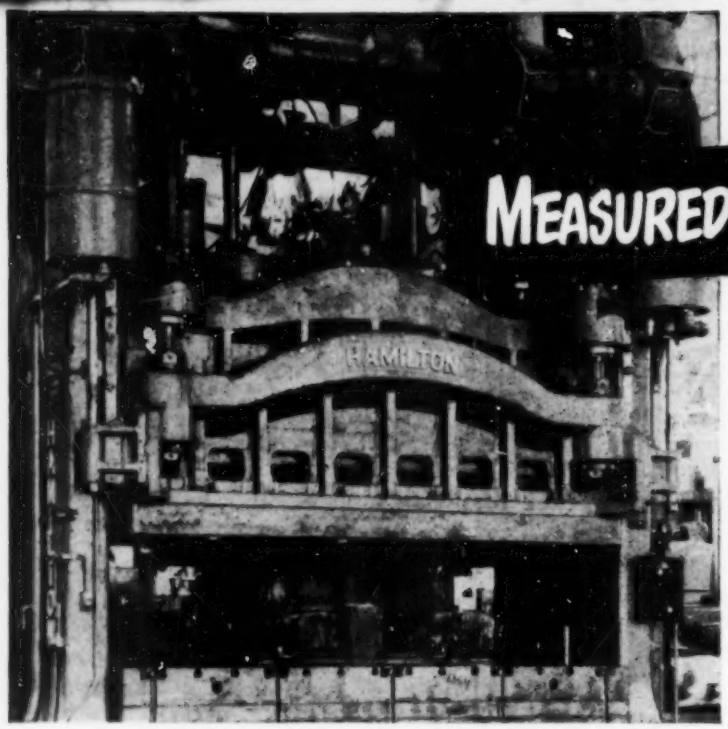
Chromaster

Write for cost-cutting free information today!

Industrial Chrome Division
Ward Leonard Electric Co.
63 South Street,
Mount Vernon, N. Y.

Please send me complete information on Chromaster industrial chrome plating

NAME .....
COMPANY .....
ADDRESS .....
CITY ..... ZONE ... STATE .....



MEASURED LUBRICATION

SOLVES YOUR BEARING SITUATION

What used to be done by hand is now done *automatically.*

We're referring to your specification of a Trabon lubrication system, which absolutely guarantees that the right amount of oil or grease will be delivered to vital bearings, at the right time and in the right place.

Our patented progressive feeder system assures this measuring-cup accuracy because the operation of each feeder depends on the previous feeder having operated first.

WE HAVE 2 BASIC SYSTEMS:

TRABON REVERSIBLE SYSTEM

This system is simply a lubricating pump and a series of reversing feeders, connected with a single line of pipe or tubing, forming a continuous sealed circuit running from the pump, around the machine and back to the pump. As the lubricant oil or grease travels, it operates the metering piston of the first feeder in the line, which discharges an exact volume of lubricant to the bearing connected to that outlet. The operation of this piston exposes a port in the feeder, thus permitting the lubricant to flow on through the circuit to the next feeder in line, where the operation is repeated. When the last feeder has discharged its lubricant, the main flow travels back to the pump where it operates an indicator stem, thereby giving visible proof that the circuit has been completed.

TRABON MANIFOLD SYSTEM

The Trabon Manifold Systems are single line combinations of feeders or measuring valves, with no external moving parts and no soft packings, which accurately proportion the volume of lubricant discharged by a pump (either manually or automatically) to the bearings of a machine. The feeder sections are manifolded into distributor assemblies to serve groups of bearings. One assembly, the first one from the pump, often serves as a master block, feeding secondary assemblies, which in turn discharge the correct volume to each connected bearing. The "M" and "MX" feeders are the same type, the "MX" being the larger.

Get *your* bearings on a Trabon system.

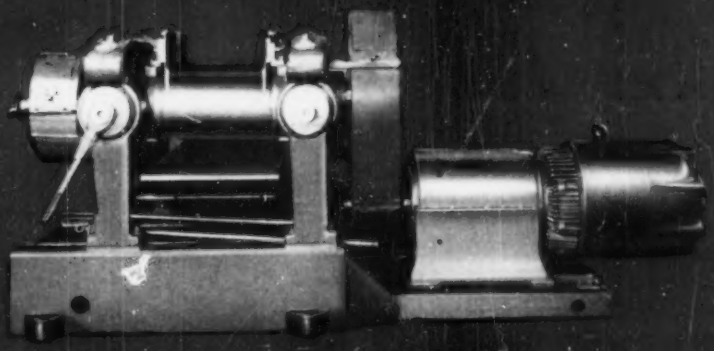
Trabon Automatic Lubrication Fits Any Bearing Situation

Bulletin 529 will give you more details.

Trabon ENGINEERING CORPORATION

1814 E. 40th STREET • CLEVELAND 3, OHIO

Oil and Grease Systems



When you use a power drive which is an assembly of motors, pulleys and belts, chains and sprockets, gearing, speed reducers, etc., you waste time and money in purchasing, handling and assembling these various units into the final drive.

Master power drives designed as complete units with component parts matching size for size and rating for rating offer you considerable saving in space and money . . . especially in the larger sized units.

best for the BIG ones too

So don't put up with "make-shift" assemblies when you can select from Master's broad line, standard units which easily combine to give you the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features in one compact unit that you can use RIGHT where you want it.

Use the RIGHT power drive to increase the saleability of your motor driven products . . . improve the economy, safety, and productivity of your plant equipment. That's the horsesense way to use horsepower.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

MASTER GEARMOTORS

1/8 TO 125 HORSEPOWER

McCormick cotton picker uses

GRAMIX® bearings

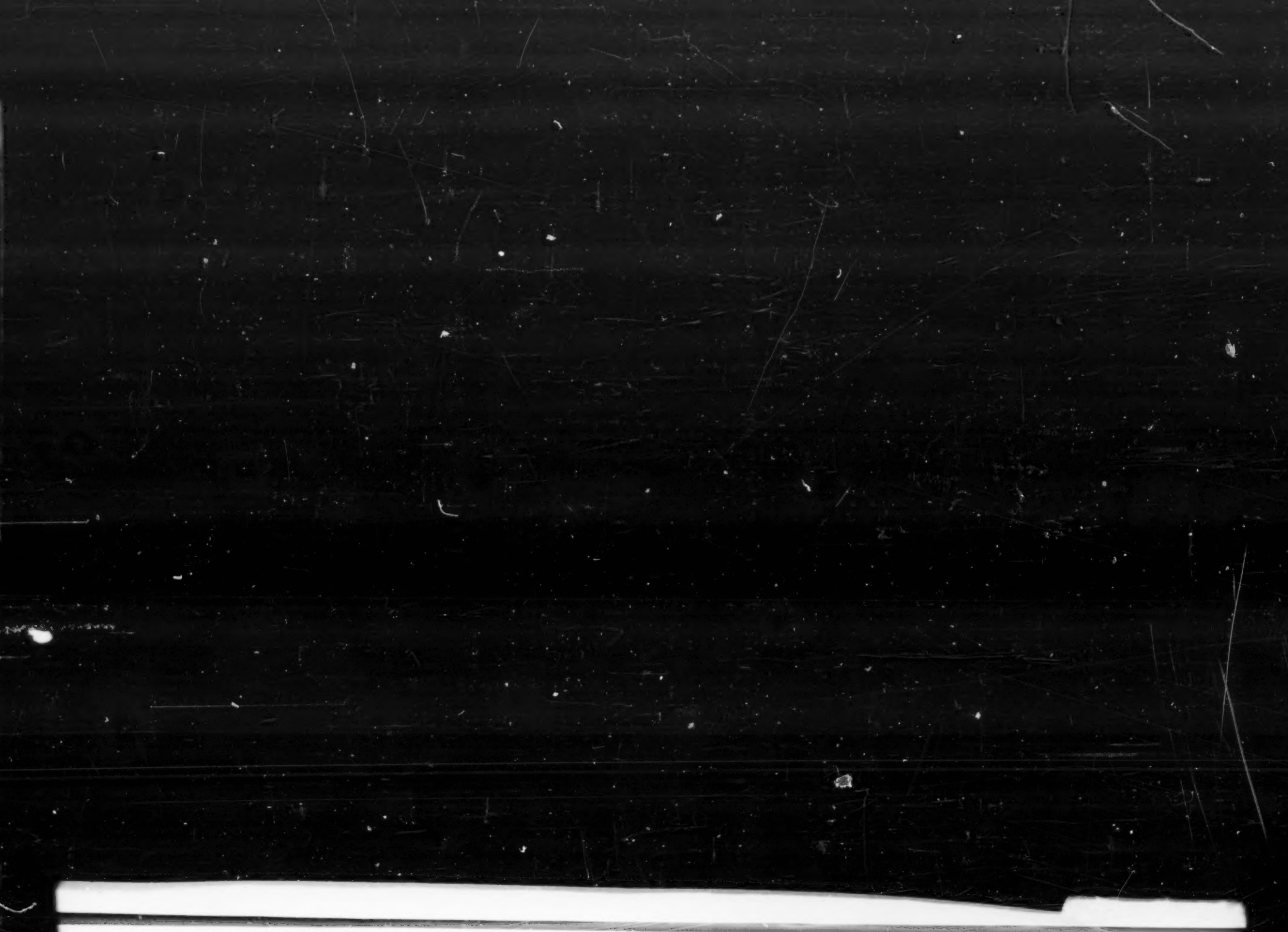
As one of International Harvester's big high-drum type McCormick Cotton Pickers moves down a row of cotton, 600 barbed picking fingers, rotating at speeds up to 2700 r.p.m.'s, pluck the cotton from the open bolls. And bronze GRAMIX bearings, on the barbed fingers, help make the successful operation of this ingenious picking device possible. This is typical of the way GRAMIX parts have helped improve many products and made the development of many other products possible. ✓ ✓ ✓

GRAMIX is produced from metal powders, compacted under pressures up to 70,000 psi and sintered at high temperatures to form strong, tough alloyed metal parts that will usually outperform and outlast parts produced by old fashioned machining methods. GRAMIX bearings and other specialty parts can be die-pressed into fairly intricate shapes with tolerances as close as .0005". They require little or no machining, thus saving man-hours of production time and greatly reducing scrap loss and waste. Because of their porous structure, GRAMIX parts require less metal and they can be oil-impregnated during manufacture to insure a constant oil film at the bearing surface. Chances are the special properties and characteristics of GRAMIX can help cut costs and improve the performance of your products. For complete information about GRAMIX, write us today.

GRAMIX bearings like this help the barbed fingers of the picking unit operate so efficiently in the amazing McCormick Cotton Picker.

95

PICKING FINGER. Note GRAMIX bearing at base.

THE UNITED STATES GRAPHITE COMPANY

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